Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

NOVEMBER, 1915.

AN IMPROVED METHOD OF LOCALISATION OF FOREIGN BODIES BY MEANS OF *X* RAYS.

By C. G. BLAKE

(*Radiographer to the Royal Hospital, Richmond*).

In order to locate the exact position of a foreign body by this method two photographs are taken on the same plate from different positions; and it is necessary to know the following factors, all of which are self-registered on the plate, so that it is not necessary to make any preliminary measurements.

It is necessary to know—

(1) The exact points on the plate over which the *x* ray tube stood when each exposure was made. The distance between these two points (see L and L^1 in Figure 278) shows the distance that the *x* ray tube was displaced between the two exposures.

(2) The distance between the two shadows of the foreign body on the plate D and D^1.

(3) The height of the *x* ray tube from the plate when each exposure was made.

One of the greatest advantages of this method is that any *x* ray tube on any form of tube stand can be used, and the only other apparatus necessary is one *x* ray plate, the "localiser," and a small metal "triangle," or "marker."

The localiser consists of a small block of hard wood, or wax (which is transparent to the *x* rays), in which are embedded two small metal cylinders, T and T^1, about 6·5 centimetres apart, and halfway between them is embedded a "height-finding" needle, N (ten centimetres high).

The triangle or marker is moistened, either with marking ink or silver nitrate, and placed between the patient and the photographic plate. The numbers 1, 2, and 3 are attached to the sides of the triangle, and these numbers and the triangle leave their impression on the patient's skin. One of the sides of the triangle is extended to form a convenient handle.

The localisation is carried out as follows:—

The triangle and patient having been put into position on the plate, the localiser is placed near to one end of the plate (see Figure 278), so that its cylinders and height-finding needle are perpendicular to it.

The *x* ray tube is now placed anywhere above the plate, preferably over some such position as L, Figure 278, at any height, and an exposure made. The patient and plate remaining unmoved, the tube is now moved across the plate, and a second exposure is made over some such position as L^1. The distance the tube is moved between these exposures need not be measured.

The resultant negative shows two shadows of the height-finding needle N (see Figure 278), two shadows of the foreign body D and D^1, one shadow of the triangle, and two shadows of each of the cylinders T and T^1. Where the two shadows thrown by each cylinder cross, there is a very dark shadow, with well-defined edges. Pencil lines are now drawn down these edges (see Figure 278), and the two points L and L^1, where these lines intersect, indicate the position over which the tube stood when each exposure was made, and the distance

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between them is the distance the tube was displaced between the two exposures. The exact position of the bullet relative to the ink mark of the triangle on the patient's skin is found by the intersection of the lines LD^1 and L^1D. I must mention here that the use of the metal cylinders for finding points L and L^1 was described some years ago by Burrell.

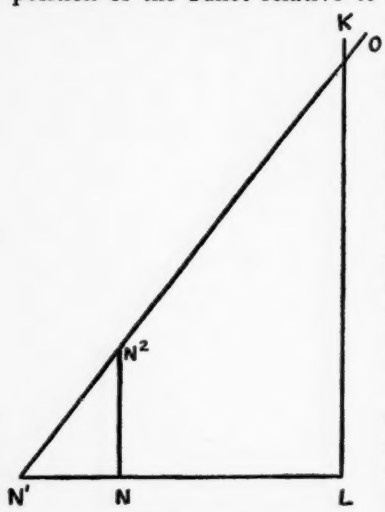

FIGURE 275.

Only one more measurement is now required, and that is the height of the *x* ray tube from the plate.

This can be found graphically as in Figure 275. The distance from L to N on the plate is set off on a horizontal line, and from N a distance NN^1 to the length of the shadow of the height-finding needle. A line NN^2 ten centimetres long, equal to the length of the height-finding needle, is now drawn vertically from point N, and a line LK is drawn parallel to this from L. A line drawn from N^1, just grazing N^2, intersects LK at O. LO = the height of the *x* ray tube from the surface of the plate.

The height can be found mathematically as follows:

As the length of the shadow of the height-finding needle NN^1 is to the actual length of the needle (ten centimetres), so is the distance of N from L, plus distance NN^1, to the height of the tube.

Example:

$$N^1N : 100 \text{ MM} : : N^1N+NL ;$$
$$25 : 100 : : 25+150 ;$$
$$4 \times 175.$$

Height of tube = 700 MM.

The depth of the bullet is now found by the following formula:

$$X = \frac{DH}{D+L}$$

where X = Depth of the bullet.
D = Distance D to D^1.
H = Height of tube.
L = Distance L to L^1.

To save the trouble of making this calculation, the depth may be arrived at graphically as follows (see Figure 276):

Two lines, AB and AC, of indefinite length are drawn at any angle to each other; a distance, AH, is marked off along AB equal to the height of the tube H, and a distance, AD, equal to the distance D to D^1, is marked along AC, and a distance, DL, equal to the distance between points L and L^1, is marked off from D to L. H and L are now joined, and a line, DM, is drawn parallel to HL, which intersects AH at O.

Distance OA = the depth of the bullet from the surface of the plate. Where several pieces of bullet or other foreign body are present, they can all be localised by this method from one negative.

In order to give the surgeon in charge of the case every assistance in marking the exact spot on the patient's skin below which the foreign body or bodies will be found, he is given a tracing from the negative or from a print on a small sheet of stiff, transparent celluloid, showing the triangle, and also the exact position, X, of the foreign body. The surgeon has then only to hold this against the patient so that the triangle fits exactly over that marked on the patient, and mark the point X by pricking a small hole through the celluloid. It must be remembered that the surface of the celluloid represents the surface of the *x* ray plate, and it is from this surface that all the depths must be measured.

The Medical Supply Association, of Gray's Inn Road, has made this localiser to my design, together with a calculator for finding the height of the tube and the depths of foreign bodies without calculation.

One of the greatest advantages of this method is that the plate when taken constitutes a complete record of the original height and position of the *x* ray tube, and also of the depth and exact position of the foreign body or bodies.

Figure 277 shows two pieces of shrapnel in a patient's knee, taken for Dr. Gardiner for the

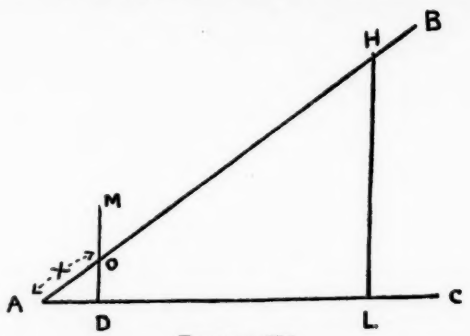

FIGURE 276.

Richmond Red Cross Hospital, which were localised by this method, and successfully removed by Mr. Swinford Edwards.

The Medical Supply Association has recently placed an improvement of my design on the market, whereby this method is employed on an ordinary *x* ray couch, with the plate above and the *x* ray tube below the patient. It can also be used as a screen method.

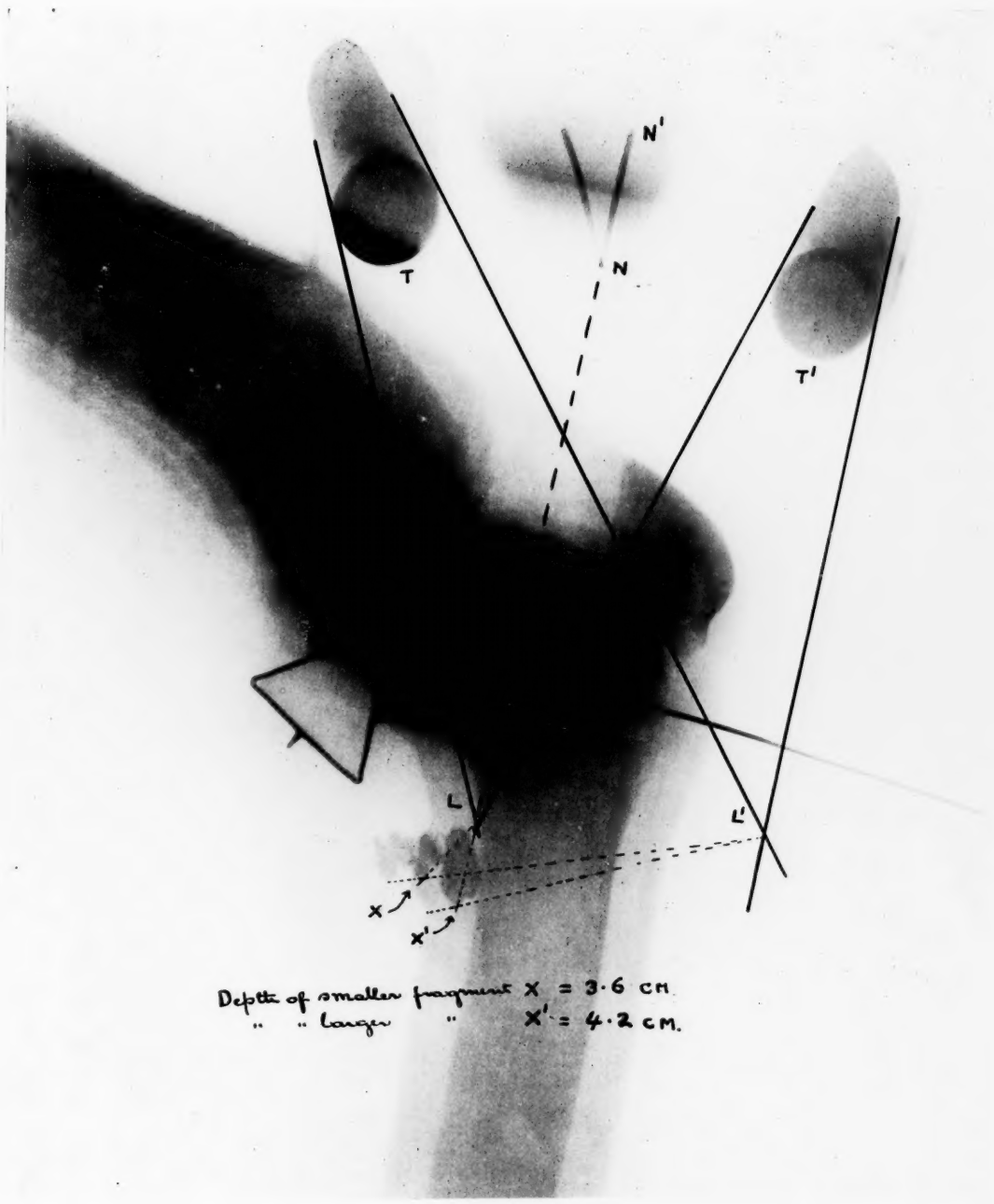

FIGURE 277.

Sciagraph showing two pieces of shrapnel in a patient's knee in the Richmond Red Cross Hospital: they were successfully removed by Mr. Swinford Edwards.

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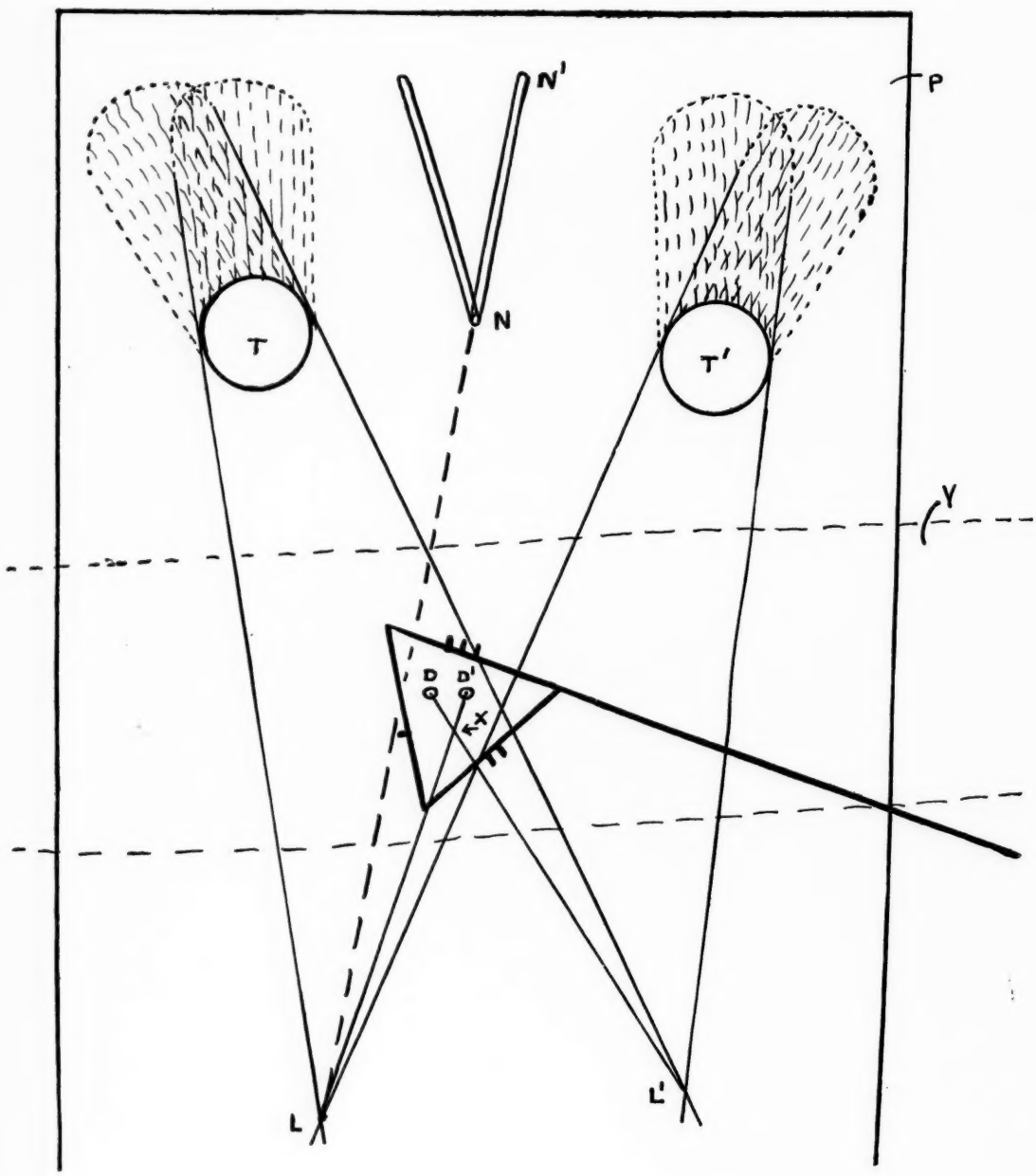

FIGURE 278.

Diagram illustrating the method of localising foreign bodies by means of *x* rays.

THE GRAPHICS OF GRAVITATION.—III.

By PROFESSOR A. W. BICKERTON, A.R.S.M.

Their Scope.

The number of lines of research which these simple graphics of gravitation open out is quite surprising. But this concluding article will deal only with the more basic aspects of some of the many problems.

The graphics of capture alone present us with an almost endless class of problems that in its varied forms of capture and release gives much illuminating insight. Where the problems are complicated with the atom-sorting in the unstable third body, as they generally are, they appear to give suggestions as to causes why the so-called earlier stars, O and B varieties, seem so rich in spectroscopic binaries, whose orbits, if we exclude the Cepheids and Geminids, are small and nearly circular, and whose periods are short; why also, on the other hand, the binaries of the class of F and G have such long periods and eccentric orbits. Nearly all the binary stars, far enough apart as to be seen as separate points of light, are of these classes. Extraordinary as it may appear, nearly all the Cepheids and Geminids, in spite of their rapid revolutions, are also F and G classes, the reason being that, the gravit centre having been cut, a nucleus was left by the third body.

These graphics give suggestions why the stars should be classified into solar and primordial stars, or perhaps better names are " gravit " and " levit " stars. Our Sun can never have been, and can never become, a Sirian star.

The problems of the equilibrium of free gaseous cosmic spheres on which these ideas are firmly founded will only be dealt with sufficiently to see the basic value and the scope of its action. The same may be said of the formation and interpenetration of primordial and sidereal cosmic systems of varying orders.

The Graphics of Partial Impact.

In the event of collision between similar suns, or any pair of similar masses, it is more probable that the impact will be of a grazing character than centre to centre. The result of such graze is an example of augmented energy of supreme importance. In the case of the partial impact of two bodies similar to our Sun, supposing only one-tenth of each stood in each other's way, the velocity acquired by mutual fall from stellar distance would cause the torn suns to pass each other.

The portions actually colliding would largely destroy each other's onward motion: they would coalesce and form a third body. The arrested molar motion would largely become molecular motion—that is, heat.

If we have two pairs of similar suns—one pair, A, ten times the mass of another pair, B, of the same volume—we have already seen that the energy of formation of the pair of dense suns is as the square of the mass—that is, one hundred times. So also at the complete collision of the pair A the kinetic energy of their mutual fall will develop one hundred times the thermal energy of the complete collision of the pair B. If in a partial impact a tenth be mutually torn from the pair A, this coalesced third body will possess approximately one-tenth of the energy that the complete collision of the pair A would develop.

Call the third body C. Then at birth C would have the same mass as the body produced by the complete coalescence of the pair B, and would possess ten times its energy (see Figures 279 and 281). This is the most interesting case of augmented energy we deal with in cosmology, as its principles are universal (see below).

This energy renders the body C thermodynamically unstable. It is an exploding sun, and dissipates into separate atoms. The pair of torn suns are unequally heated revolving stars. These may be wedded into binary stars by the temporary attraction of the third body.

It can be deduced from the chemico-physical properties of the third body C that it must frequently divide into a nucleus of heavy elements surrounded by an expanding shell made up largely of light-gases. These will produce the light-curves and series of spectra that are characteristic of novae, as discussed in many volumes of " Knowledge," in " The Birth of Worlds and Systems," and more recently as observed in Nova Geminorum. These light gases will pass through a planetary nebular stage. In some cases these nebulae may last thousands of years. Their high velocity suggests that they are third bodies.

It can de deduced also that this condition of thermodynamic instability in a third body applies equally to the portions actually colliding in the grazes of meteoric swarms and of nebulae. It also applies during the interpenetration of sidereal and other cosmic systems.

It is consequently of prime importance in the study of many celestial problems, quite apart from its interest in connection with stellar impact.

This stupendous energy is the most obvious of the many properties the third body possesses. Its potentiality in its many modes of production seems endless. The neglect to study this explosive third body has doubtless been the cause of much of the failure to explain astronomical phenomena in the light of recent spectroscopic observations.

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There is actually no known example of the multiplicity of the spectrograms of novae but can be satisfactorily explained on the theory of the third body, and generally the physical agents that explain the spectra were deduced years before the spectrograms had been taken.

THE GRAPHICS OF CAPTURE.

The third body possesses a great capturing power, and will generally wed the colliding suns into a double star. It must be remembered that this capturing power is equally true of grazing nebulae or cosmic systems. This power to capture is lessened if the two colliding bodies or systems have their energy augmented by proper motion or by the attraction of other bodies. The many agents modifying capture are very complex. The important ones are given below.

In this study we shall assume the collisions to occur at critical kinetol without augmented energy.

Suppose a part, say one-tenth, of each of the similar bodies be struck off and coalesce.

Each remainder would have a mass of nine-tenths, and the third body will be two-tenths—one-fifth of the original mass of either. The attractions at any given distance of each of the bodies after they are sheared will, of course, be proportional to mass—that is, each original body will be $\frac{9}{10}$, and the new body $\frac{2}{10}=\frac{11}{10}$; that is, for similar distances the attraction on each unit of mass will be one-tenth greater than before. It is easily seen in Figure 279 that the new body being at rest between the retreating pair will only increase its distance from each at one-half the rate at which they leave each other; hence at each infinitesimal of distance it will act twice as long. So that the retarding action, compared to what it would have been had the bodies only grazed without actually striking, will be $\frac{9}{10}+\frac{2}{10}\times 2=\frac{13}{10}$.

WHIRLING COALESCENCE.

When a third is struck from each of two similar bodies an interesting phenomenon ensues. It also ensues with more than a third. It applies especially to nebulae. Of course, the impact makes three equal bodies, each two-thirds of either of the original bodies. But the capturing power is now $\frac{2}{3}+\frac{2}{3}\times 2=\frac{6}{3}=2$; that is, the bodies, were they to become spherical, would use up their kinetol in becoming three spheres in contact (see Figure 280).

Had they not collided they would have passed away to infinity; but the attractive power has just doubled, so that they can only double the distance of their radii, as we know by the kinetic curve. To do that uses up half their energy to infinity. Of course, they do not actually become spheres: they tend to spread, by the mutual action of attraction and kinetol, into a bun-shaped rotating mass, with a central furnace, from which material is ejected axially (see Figure 282). This is called "whirling coalescence" and "axial extrusion."

In the case of the collision of similar spherical nebulae it must produce a double spiral.

The action of axial extrusion shows in many of the spectra of nova, and is a most fascinating study. The material ejected may also be seen as a haze in the photographs of many oblique double spiral nebulae. It is especially noticeable in the magnificent photographs of the nebulae in Andromeda and spiral nebula M 81 Ursae Majoris (see "KNOWLEDGE," page 451, December, 1911).

This portion of the graphics of gravitation is more particularly interesting in the interpenetration of widely diffused masses, such as nebulae and cosmic systems of different orders.

But before treating of the graphics of cosmic systems we must say a few words on the gravitation graphics of atomic motion. Our space will only allow of these to be treated from the standpoint of velocity and kinetol.

THE GRAVITATION GRAPHICS OF ELEMENTARY MONOTOMIC MOLECULES.

Elementary molecules vary in the number of their atoms from one to six; but generally at stellar temperatures it is assumed that they are dissociated into single atoms. Hence we shall treat our gases as monotomic molecules.

Monotomic molecules of different elementary gases, at the same temperature, have equal energy; and, as kinetol is energy divided by mass, their kinetol is inversely as their atomic weight; hence the power to escape from an attractive source is inversely proportional to their atomic weight. The atomic weights of hydrogen, helium, and oxygen are respectively 1, 4, and 16; hence their kinetols are 1, $\frac{1}{4}$, $\frac{1}{16}$ (see Figure 283). But velocity is proportional to the square root of kinetol, so the velocities are 1, $\frac{1}{2}$, and $\frac{1}{4}$ represented graphically (see Figure 284). Hence, as fully discussed in "KNOWLEDGE" and elsewhere, we have atom-sorting, or "selective molecular escape," that gives ensphering shells around an exploding nova. But the number of atoms is inconceivably great, that they act as a hurrying crowd, and the fast push the slower ones on; so that it is only at the outside of the vast expanding sphere that the light atoms escape freely. This entangling of the elastic atmosphere of molecules is called "gaseous adhesion." By taking these three factors and the oscillation of the nucleus of the third body into consideration there is not a single peculiarity of all the long series of the spectra of novae but may be explained.

When we take all the elements instead of three, other interesting peculiarities show themselves that form the basis of the dynamical theory of the photosphere, and give the reason for the different orders of stellar spectra (see Figure 288).

Notice that hydrogen has four times the kinetol of the next known element, helium; it has also twice the velocity. Helium has not quite twice the kinetol of the next element, lithium; and in

other elements the difference of the kinetol from that of the next element is very slight. This causes the elements to mix. It is probably this mixture of elements that causes the photosphere. Hydrogen and helium tend to form a layer above the general surface of gaseous statical equilibrium in the Sun and stars.

But helium is really widely separated in its kinetol from hydrogen, and is close to other elements; hence it tends to fall out of the levit layer of hydrogen, and pass into the photosphere; so that, as astronomers on other grounds think, the helium stars are probably younger than the Sirian stars.

The whole of atom-sorting and its graphics is full of interest, but is very complicated. Some forty-five years ago a number of chemical, electrical, and other physical facts suggested that atoms had a comparatively large elastic atmosphere. This idea was followed up by a number of experiments, and some of them were published as a paper on heat and electricity in *The Philosophical Magazine* for December, 1873. One of the most salient facts on which this idea was founded was gaseous adhesion, the property of molecules that causes the need for the spin of a projectile. My studies of the spectrograms of novae suggest that in the case of very violent explosions, such as an exploding sun, so long as the gas remains very dense this gaseous adhesion is so powerful as largely to overcome the law of Graham, and to carry the heavy molecules along with and almost at the same speed as the light molecules. This is probably also true in the metallic projections of the Sun.

Consequently in the convection currents of very hot dense gases we have an agent that tends to prevent the elements of a star arranging themselves in layers according to their density, from the centre outwards.

The disturbances that tend to produce convection currents in a sun probably have their origin largely in meteoric bombardment. Hence it is reasonable to suppose that, as we approach the centres of suns, the elements are arranged roughly in the order of their atomic weights. The tendency of the very heavy atoms to break up and give off helium may have an important compensatory cosmic effect in disturbing this central segregating action. This action will render them more easily volatile when in the central furnace.

Our graphics of gravitation have shown us the stupendous detonating effect of meteors striking the Sun's surface, and the still more powerful dynamic effect of this trigger action by liberating the Sun's energy.

This is probably the cause of the seething surface of the Sun. The whole photosphere is so stirred that continuous convection currents rapidly bring heat to the surface, to compensate for the tremendous radiation.

We are now in a position to understand the intense heat of the photosphere. It is simply the rough outside limit of equilibrium, the (so to speak) statical surface of gaseous pressure. It is the surface of separation between the general gravit mass of the Sun and its levit chromosphere, the two being kept apart by the great step from the kinetol of 1 to that of, say, $\frac{1}{25}$. Below the photosphere the Sun gets still hotter. The reversing layer is probably the average depth of ejection, the top surface being, roughly, the general limit of this metallic outpour. It is the average height to which the incessant volcanoes produced by the solar energy, under the detonation action of meteors striking the gravit solar surface, project the Sun's gravit material beyond the photosphere.

Thus these two graphics of atomic kinetol and atomic velocity, combined with gaseous adhesion, give an explanation of these three solar layers. The photosphere is the general limit of solar equilibrium. The reversing layer is the region of volcanic disturbances, and the chromosphere is the layer of light atoms kept separate by high atomic kinetol.

It is probable that all luminous stars have some heavy elements that form the gravit portions of the stars, and the exterior surface of this nucleus is the photosphere. But the quantitative ratio of hydrogen and other elements must differ enormously, according to whether the suns originate amongst white nebulae or gaseous nebulae. A sun originating in the nebulae of Orion would be a hydrogen or Orion-star, with perhaps very little heavy metal in its nucleus or gravit centre; hence is altogether a comparatively rare star, even below its photosphere. Perhaps this may have much helium in it. The dynamical theory of gases suggests that there must be some strange concentric segregating action at work in the formation of primordial cosmic systems.

Whilst, on the other hand, stars formed of white or dust nebulae must be of the character of solar stars, so, according to their origin, we get Carbon stars without perceptible hydrogen (possibly it is there as water), Antarian stars with so little hydrogen that its pressure does not give heat sufficient to dissociate oxide of titanium, Solar stars with one per cent. radius of levit layer, Procyon stars with one to ten per cent., Sirian stars with ten to twenty-five per cent., Orion stars with twenty-five to forty per cent., Bright-line helium stars with forty to sixty per cent., Wolf-Rayet stars with fifty to ninety per cent., and such a star as Campbell's star (DM+30°·3639) with ninety-nine per cent. of radius of chromosphere and one per cent. below the photosphere, that is, a volume of a million to one of chromosphere. Figures 285–287 and 289, 290, and 292 show six of such stages. Thus there are two kinds of bright-line stars, such as Mira and γ Cassiopeiae. Mira is a cool star that has been injured by an impact. It shows the fluted spectrum of compounds, and hence is cool, but is hot in one part. Mira seems to have a long, vast volcano on its

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equator. Along this intensely hot valley tornadoes of heated hydrogen rush upwards, and give us its bright lines, some of which are absorbed by cooler hydrogen higher up. The different upward speed of its varied convection currents and the varied activities of its pulsating volcano account satisfactorily for most of its peculiarities, as in all volcanoes there will be periods of greater and lesser activity. A similar explanation may account for all the long-period bright-lined variables; whilst, on the other hand, we have the steady star, γ Cassiopeiae, with its small brilliant photosphere, shining through its enormous chromosphere, and producing reversion of the high overtones of hydrogen; whilst the vast self-luminous chromosphere gives us its low bright lines and splits them by reversion through its cooler exterior.

Our graphics explain a number of the characters of spectroscopic binaries.

There are several grades and classes of these close double stars. Campbell gives a wonderful classification in his table (XXVI, page 260, of his "Stellar Motions").

We have shown that the idea of age is apparently only one factor of star class. Chemical composition is probably a more potent agent.

It is ordinarily assumed that doubles have generally been formed by tidal division. Now tidal division depends on the rapid rotation of bodies, and stars do not, as a rule, rotate rapidly; yet there are innumerable spectroscopic binaries, especially of levit stars. So we want alternative explanations.

The graphics of gravitation suggest that spectroscopic binaries have been formed by being captured by the third body of a grazing impact. Nearly all the facts that characterise these stars agree with deductions from the graphics of capture.

Let us temporarily assume that the so-called earlier stars are really levit stars—that is, stars of low density—because they are chiefly hydrogen, and that all but dead or dying levit stars have a photosphere low down in the star, this being the bright surface of a very hot central globe of mixed gases. This nucleus is many times denser than the chromosphere. The photosphere may be of non-metals such as C, N, and O, or made up largely of metals such as Ca, Al, Fe, Ti, and so on, possibly classes B and O; that is, the ordinary helium stars and all steadily shining bright-line stars have photospheres largely non-metallic. Procyon and A stars appear to have much metal. In G and K stars the photospheres are almost wholly metallic, and have but little chromosphere, whilst the Antarian stars have still less chromosphere. The giants seem to be very rare, yet the photosphere is largely metallic. They probably become Solar and Procyon-like, and back again to dying dwarf M stars. The carbon stars have no chromosphere, any hydrogen present being probably water.

Necessarily, the third body will always be largely made up of the outsides of stars. This, in the case of very levit stars will be almost wholly hydrogen; but even these stars may strike deep enough to cut the photosphere. Grazing gravit stars—that is, Solar and Antarian stars—*must* cut the photosphere, but a photosphere is a gas surface, and old stars may have a liquid or solid nucleus, and hence have no photosphere. Still, the dead nucleus may be cut.

Then the star will have a scar, a vast volcano, a fiery lake that may last a thousand years. In this case we have long-period variables. Cepheids or Geminids may result (see Figures 279 and 281). When the surfaces of the nuclei of stars are cut, atom-sorting ensues, and the third body divides into a nucleus that remains and causes an eccentric orbit (see Figure 291). The ensphering shell is alone dissipated into space.

On the other hand, if its chromosphere (the levit layer) is large, it may graze deeply, and the third body may have considerable capturing power; but, as only the chromosphere collides, the third body is then all light-gas, and may entirely dissipate. Here our graphics say we shall have no nucleus left to cause an attraction on return, and hence the result is a spectroscopic binary of short period, and is of circular orbit—the deduction strikingly borne out in all Campbell's tables.

But this is not a treatise on stellar motion: it is an attempt popularly to explain the graphics of gravitation, and their extraordinary fertility in solving some of the vast variety of problems of astronomy that have been opened up by the spectroscope.

We must pass on to the subject of the proper motion; also to the relative kinetol of such bodies as our Sun, as compared with such vast stars as Canopus, with nebulae and with sidereal systems.

The Critical Kinetols and Velocities of Suns and Cosmic Systems.

The law of attraction of a ring or of a bun-shaped mass, and of a sphere, is not the same. Newton discussed the difference in the "Principia," but here we shall only treat of systems as though they were spheres. Let us compare the Sun and the giant star, Canopus, that many astronomers consider to be more than a million times the mass of our Sun. Let us call Canopus a million times the mass of the Sun, and our sidereal system a thousand million times its mass. If we take our Sun as units of mass of radius and of density, and Canopus as unit-density and a million units mass, it will have a hundred units of radius. Take our sidereal system as a thousand million units of mass and having a radius of six thousand light-years. What are the critical kinetols and the critical velocities of the surfaces of these spheres? In the case of the sidereal system the critical velocity will be the maximum proper motion that a star may possess to avoid flying away and completely leaving the sidereal system.

If Canopus has the same density and a million

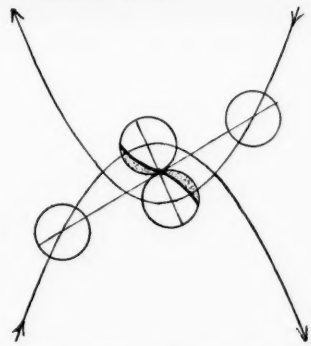

FIGURE 279. Notice the lines joining the suns have revolved more than a right angle; hence the tidal action has entirely broken any crust there might be. The shaded portions will be cut off.

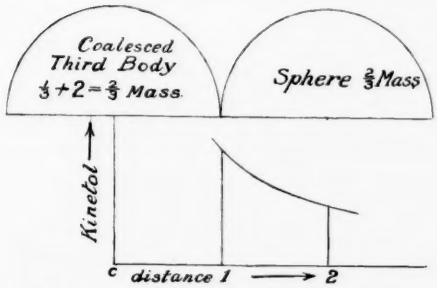

FIGURE 280. Graph of whirling coalescence.

Three equal bodies doubling the attractive energy and travelling to only one radius distance.

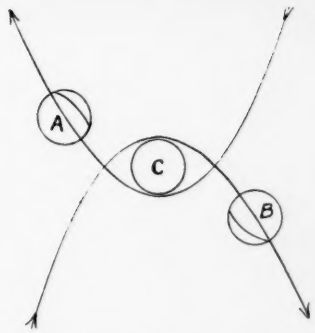

FIGURE 281. C is the coalesced third body cut from A and B, the torn suns.*

* The portions that made up C were attracted, not merely by their own mass, but by the whole of the masses of the stars. Thus, if one-tenth be cut off, then the augmented energy is nine-tenths more than mere mutual complete coalescence. It will also be seen that A and B leave each other at twice the speed they leave C, thus increasing their capturing power.

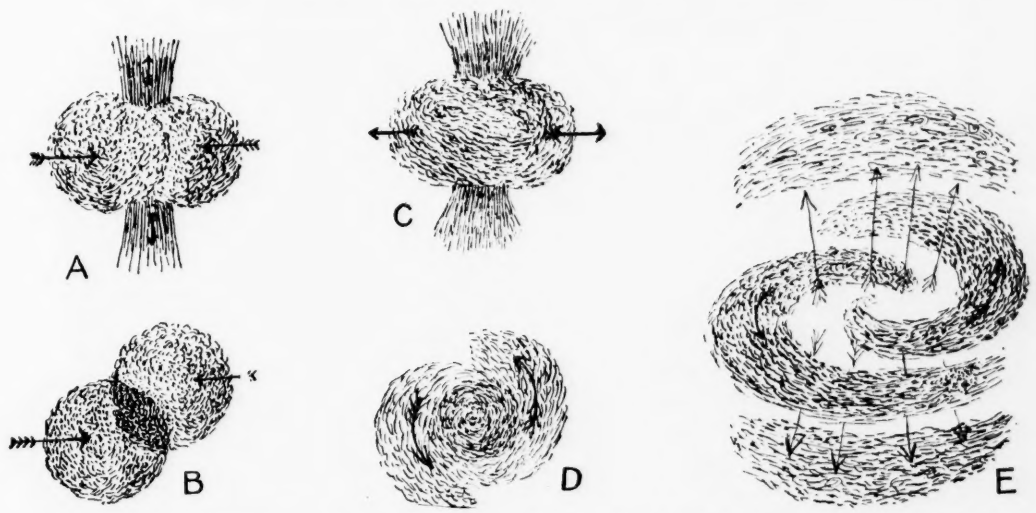

FIGURE 282. Diagram illustrating the evolution of White Spiral Nebulae and the Galactic System.

A and B, plan and elevation of cosmic systems coming into impact. C and D, the same in which the impact has advanced to a state of a whirling coalescence. E, an oblique representation of the two polar caps of Nebulae, and the double spiral of stars and other matter forming the Milky Way, tilted towards us. In A and C is seen axial extrusion expelling matter perpendicularly to the plane of the whirl.

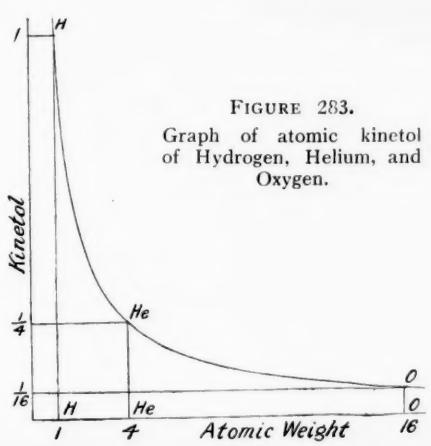

FIGURE 283.

Graph of atomic kinetol of Hydrogen, Helium, and Oxygen.

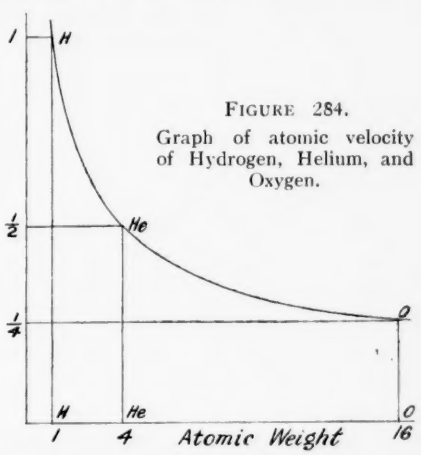

FIGURE 284.

Graph of atomic velocity of Hydrogen, Helium, and Oxygen.

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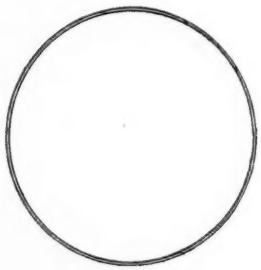

FIGURE 285.

Solar star with only one per cent. radius of chromosphere. Antarian stars have still less, and the carbon stars show none.

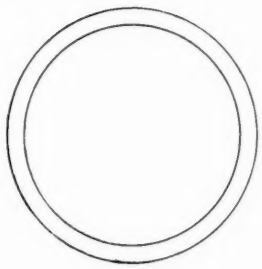

FIGURE 286.

Procyon and Canopus stars. The inner circle is the photosphere, that is, the outside of the gravit nucleus.

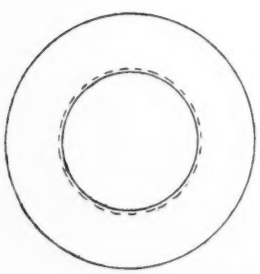

FIGURE 287.

Sirian stars. The dotted line shows the highly heated hydrogen that gives the wings to the bands.

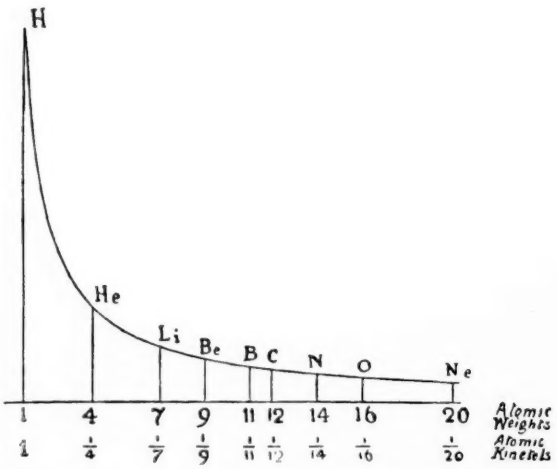

FIGURE 288. Graph of atomic kinetol of all known elements up to atomic weight of 20.

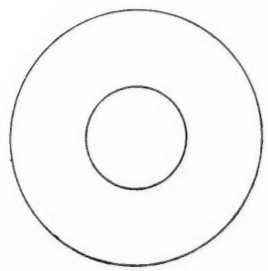

FIGURE 289.

Orion stars with photospheres slightly larger than inner circle. Bright-line helium stars, with photosphere slightly less than the circle.

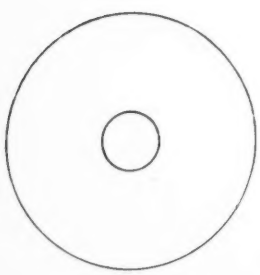

FIGURE 290.

Wolf-Rayet stars. γ Cassiopeiae. The light shining through from the nucleus has reversed lines. The light from the chromosphere gives bright lines. The high overtones hug the nucleus and show reversion.

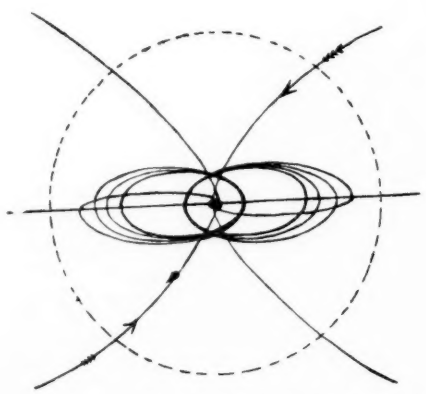

FIGURE 291. Diagram showing the formation of the orbit of a double star.

The dotted circle represents the nebula expanded beyond aphelion distance. The two continued hyperbolas represent the path of the two stars had there been no collision. The collision occurring, the orbit becomes a long ellipse that becomes of less eccentricity, because the nebula has expanded.

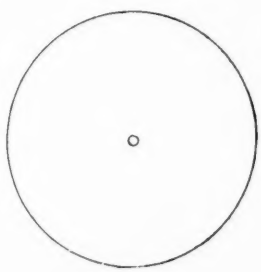

FIGURE 292.

Campbell's Star. MD+30°·3639. The nucleus may be of solar dimensions. The levit mass shows a crimson disc of 5″ diameter.

times the mass of the Sun, it will have one hundred times the radius. Hence its critical kinetol will be $\frac{10^6}{10^2}=10^4$, that is, ten thousand times that of the Sun, and the critical velocity will be $\sqrt{10{,}000}=100$ times that of the Sun. The Sun's critical velocity is four hundred miles a second, so that the critical velocity of Canopus would be forty thousand miles a second. A meteor falling at critical velocity on Canopus would develop ten thousand times the heat it would if it fell on the Sun.

In the case of our sidereal system we may take the mass to be that of a thousand million suns, and its radius six thousand light-years. Now a light-year is, roughly, 6,000,000,000,000 miles. So the critical kinetol compared with the Sun is

$$\frac{\text{mass}}{\text{radius}}=\frac{10^9}{10^{11}}=\frac{1}{10^2}=\frac{1}{100}.$$

Hence the velocity is $\frac{1}{10}$ of solar critical velocity=400; that is, forty miles a second. An atom or a sun with, say, fifty miles a second velocity will leave our sidereal system to wander in space. We obtain the radius of about 10^{11} by taking the ratio of $6\times10^8\times6\times10^{12}=36\times10^{15}$, and dividing by the radius of the Sun, $4\times10^5=9\times10^{10}$, or approximately 10^{11}. Of course, all these numbers are mere approximations taken from a number of estimates, the object being to show graphic methods. It is interesting to follow the reasoning to the velocity of hydrogen and helium in the great central furnace, and it comes out as possibly of the same order as that of light.

THE GREAT CENTRAL FURNACES OF INTERPENETRATING NEBULAE AND SIDEREAL SYSTEMS.

This is the last subject we will discuss in these articles. We shall treat only oblique collision of nebulae, and the interpenetration of a sidereal system with primordial or gaseous cosmic systems of the first order (see Figure 282).

Were two purely stellar systems to interpenetrate it is conceivable that they might pass through each other with but little damage. When, however, a continuous sheet of gas is interpenetrated by a stellar system, cosmic dust and smaller bodies will quickly volatilise, and be brought to rest. As the position of the series of impacts remains practically in the same place, but will necessarily extend itself, it increases in density, temperature, and volume.

It will probably be bun-shaped. Let us consider it spherical, and discuss its growth. Let us assume that the interpenetration has gone on for some time. Then, as the temperature increases enormously, the pressure increases, possibly at a still greater rate. We will assume that it increases at the same rate, and that the density remains constant. Again, let us take a concrete example. Let us assume it has doubled its diameter. The mass is 8, the radius 2; hence the kinetol is 4; hence, as temperature is a function of kinetol, the temperature is 4; that is, the temperature of the growing central furnace of a pair of colliding cosmic systems whose density remains constant is proportional to the square of its radius.

Hence after a time, not merely cosmic dust, but also suns, are volatilised in this stupendous and fervent furnace. Probably the pressure, as well as the temperature, increases until the disintegrated atoms that radio-activity has produced may be built anew.

Lead under the swift impact absorbs helium, and becomes uranium and thorium; under this stupendous speed and pressure, helium, and perchance hydrogen, is shot into the atoms until a stable grouping causes persistence.

Picture the action as somewhat similar to the chemical dynamics that cause the formation of manganates, chromates, ferrocyanides, and so on; then the formation of heavy elements becomes intelligible. Thus suggestive are some of the deductions that result from the strange simplicity of the laws that are seen at work when looking at the graphics of gravitation. But our space is exhausted, and the more complex problems that offer themselves, when we introduce a greater number of variables, must be left until the equilibrium of free gaseous cosmic spheres under different temperatures, masses, volumes, chemical composition, and some nine other variables are treated of; then when with this dynamical basis we study the structure of the various orders of the stars, we find that we are supplied with the interpretation of the many classes of stellar spectrograms that our magnificent modern instruments have given us.

The explanations may not be final; they are at least scientifically intelligible. It has been said that truth emerges more quickly from error than from confusion.

In the past, mathematicians have been much more interested in the kinematics than in the kinetics of cosmic problems. This neglect of the study of energy has not infrequently had a retarding effect on many lines of astronomic progress. Even now embalmed corpses of many dead but like-like-looking theories still cumber the path of progress, and impede the advance of truth; thus, for example, take Laplace's theory.

The angular energy of the Sun's rotation is thousands of times too small to have ever allowed of the release of rings at all; yet so late as the publication of "The Earth's Beginnings" an attempt is made to galvanise the theory into life. Fifty years ago Morrison told us the theory had then been dead for forty years. It really ought to be decently buried.

The lifelike appearance of many other dead theories is due to their eminent advocates using their wonderful mathematical genius on applying the stupendous power of the calculus to isolated factors, instead of correlating the whole.

We may easily do much by merely using the scale to compare by measurement the five graphics

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of gravitation with the graphics of cosmic sphere formation. When kinetics are applied to the tidal fissure theory, and to the theory of the origin of spiral nebulae, we see that it is probable that other agents besides those studied must be at work, and should be taken into consideration. The same is true of the idea of novae being planets plunging into suns, and suns plunging into nebulae. On grounds of equivalent energy, when contrasted with the facts of astronomy, all these theories largely crumble to dust. Think of the stupendous angular velocity required even to double the diameter of a body. Contrast this with the actually small rotation observed in almost all stars, except spectroscopic binaries. Think, again, of the small mean internal kinetic energy of an average star compared with its critical kinetol.

Singularly enough, in addition to the stupendous number of kinetic objections to these theories, they are not in tune with the configuration and distribution of bodies in the galaxy. The extremely beautiful and ingenious tidal theory of spiral nebulae suggests the double fact that we should often find pairs of double spiral nebulae. Whereas they seem hardly ever to be in pairs; and, where stars are thick, there would be many close approaches, and consequently there the spiral nebulae would be most thickly spread; whereas spiral nebulae are seldom seen in the Milky Way where stars abound. Almost certainly white double spiral nebulae are produced by the grazing impact of the previously existing meteoric clouds. The distribution, the kinetics and kinematics all agree with the suggestion.

This is an age of specialisation, and rightly so; but the specialists should be well instructed in all the generic principles on which their detailed researches are founded, and the deficiency of this wide basic knowledge is the lack of the age. Men work in thought-tight boxes, few knowing much of the work of others. But for researches to be fertile they must be correlated with allied work. It is a valuable characteristic of the latest researches connected with radium and the solving of the nature of x-radiation that many sciences are involved; and, again, in higher technical engineering there is the same broadening of the bases of researches.

The extraordinary invasion of science into everyday life may also have a very advantageous effect on thought, and misleading partial scientific truths may be rounded to completion. Thus a true and optimistic philosophy of life, based on the productive possibility of the present, may become general, may lead to a partial blending of this possibility with a true ideal of life, and give to man what he can truly claim as his birthright—a heritage of joy.

THE INNER LIFE OF SOME COMMON PLANTS.

By P. Q. KEEGAN, LL.D.

ORDER may to men's eyes be introduced into the world of plants by classification and naming, or the plant may be mechanically dissected and the histological parts thereof scanned through the magnifier in order to ascertain their particular form or relation to other parts of the structure; but a third method is to endeavour to discern and separate the chemical compounds which the vital energies of the plant produces, and are of service for the outcome of such visible or intangible phenomena as its size, weight, rate of growth, coloration, general activity, and duration of life. In fact, we can never understand the inner life of a plant until we know something about its chemical faculties, and whether it is really similar to or distinguishable from other plants by its power of producing certain organic compounds by virtue of the peculiar quality and strength of its physiological powers of assimilation and of deässimilation. All other features are of purely mechanical or fortuitous origin: this one alone uplifts the screen of mystery that enshrouds its manner of life, the precautions and forestalments necessary to its very existence and wellbeing, its glory and panoply of coloration, its powers of resistance either to the sultry tropical sun or to the piercing fangs of winter cold. But let me now put forward certain illustrations of this mode of view, the selection being made from some common familiar plants.

Daffodil.—This tenant of open woods and pastures exhibits deep-green leaves and large yellow flowers which develop almost under any conditions, because it needs no nitrate from the soil, its roots being infested by fungi, forming an association named "Mycorrhiza." It is perennial, because there is a bulb underground, although its pollen germinates easily and with great regularity on the stigma with production of numerous germinable seeds. Its overground life is prolonged, for the leaves keep green long after the flowers have perished; while the scales of the bulbs, comparable to youngish rudimentary leaves, still support and sustain a considerable activity. Examined now chemically, we learn that the leaves are very difficult to dry, their ninety per cent. of water being held with extraordinary constancy and tenancy. Now we know that water is essential to life, and hence the reason why these very watery organs keep green and living for an unusually lengthy period. The analysis indicates a physiological process of assimilation, producing very little starch, but abundant sugar (hence copious nectar) and plenty of mucilage, oil, and wax; and a process of deässimilation, producing abundant acids and some tannoid, along with a little saponin, and an alkaloid most probably a decomposition product thereof. No tannin is observed; hence there is nothing but yellow, orange, and green colorations potent and deep; while the ash of the visible parts shows that a large amount of soluble alkaline salts, especially chlorides, are extracted from the soil for the needs of the plant. Altogether, then, we learn that the physiological processes in the case of the Daffodil are sluggish and imperfect, have little vigour or development, evolve little substance of an oxidative

character, but potent in the way of a reductive property, which means that in this plant the oxygen of the surrounding air finds little chance of invigorating the living protoplasm of the tissues.

The Primrose, " first-born child of Ver," presents some interesting features. It is also what may be called a root-plant: its erect rhizome, with its broad cortex and narrow pith, finds out a damp clay on which to live and manufacture an abundance of starch and malic acid. It contains little tannin, but instead an emetic saponin (cyclamin), doubtless a decomposition product thereof. The leaves evolve abundance of wax and chlorophyll (the Primrose revels in the shade), but yet have no tannin, save later in their narrower parts and chief bundles; but there are abundant acids and mucilage and fugacious starch, together with an ample supply of mineral matters (ash), which may yield as much as 17·2 per cent. of chlorine. The floral parts (pedicel and inflorescence) are conspicuous by the presence of carotin (at the base of the petal) and xanthophyll (towards its tip), which latter imparts a perfectly delicate coloration thereto (artists say it is really green). Here, too, do we find more tannin then in any other organ of the plant, and a tannin (it is regarded as a tannide by some chemists) of a very remarkable character. Thus when boiled with dilute mineral acid it yields a solution and precipitate of a most beautiful red colour—just the very tint, in fact, which we see staining the corolla of the cultivated Primulas in the winter time. Whence we see that the keen and passionate fervour of the poet with reference to the Primrose finds a justification in the revelations of the chemist; the secret source of colorific faculty is revealed, the gentle swaying of the petalled head that may be pure red or purple (but never blue) is faithful to the leaves as yet in rudiment of form or function; in short, the " rose, which from the prime derives its name," dreads not her annual funeral. The vitality is apparently fresh and juvenile; but, in fact, it is of sluggish temperament and of long preparedness for the fierce battle with the elements, for it really belongs to a mountain genus—it is a plant of the hills.

In striking contrast to the foregoing is the plant known familiarly as the Cow Parsnip (*Heracleum Sphondylium*), found in hedges, hayfields, etc., which has been said to exhibit a rollicking vigour, a robustious growth beyond all English flowers; in fact, " the progress is forceful, the vigour ebullient, the triumph supreme." But what on earth may account for all this amazing exhibition? Need we state that no amount of naming, dissecting, natural selectioning, etc., will ever answer this question? The root is hard and fibrous, and contains abundant starch and mucilage, also a yellowish acrid resin and some sugar, but no tannin. The large leaves, which are highly chlorophyllous, contain much resin and fat-oil, with small quantities of tannoid and caffetannin: they produce great quantities of oxalate of calcium; the starch is fugitive and forms no reserve. The peculiarity of the plant, owing doubtless to its anatomical structure, is that the nitrate which it absorbs from the soil exerts a more than ordinary influence over its growth and development. It is known that different plants behave differently towards the nitrates of the soil; in some their growth is checked, but this is not the case with the Cow Parsnip. It appears that the nitrates of the soil, when they ascend the stem of a certain structure, increase the osmotic pressure (*i.e.*, they communicate a swelling force to the cell sap), and this increases growth by acting, not merely as a mechanical force which stretches the cell-wall, but also as a stimulating irritant on the protoplasm. The latter, therefore, puts forth its greatest strength and vigour when especially the tissues are of a certain pliability and responsiveness. Nitrate is clearly detected by chemical methods in the stem and in the huge leaves. Moreover, the plant has air-spaces, interstices, and intercellulars in great variety and extent, so that the oxygen of the air is at liberty to play freely within the tissues. A rapid reformation of sugars, and so on, which increase the osmotic pressure and accelerate the growth, would serve to counteract the effect of a too liberal absorption of water from the soil.

Just at the beginning of autumn, when the moorlands get bleak and grey, and the fallow wolds and fields assume a sear and yellow aspect, we see, erect thereon, a stiff, picturesque, solitary weed with looped and curled leaves and an effusive crown of yellow flowers. This is the Ragwort (*Senecio Jacobaea*), and its loneliness on the soil is no indication that it has no relations; on the contrary, it may be regarded as a type repeated and represented by an enormous number of plants scattered broadcast over the face of the earth. But let us seek what it contains. The leaves are fortified by a considerable coating of wax, and much carotin and chlorophyll are produced thereby; also a tannoid capable of yielding brilliant " lakes " with salts of tin, alumina, and lead, some caffetannin, cane-sugar, resin, very much mucilage and oxalate of calcium, but no reserve starch. The mineral matters (ash) amount to 13·4 per cent. in the dry leaf, and yield 9·6 per cent. chlorine, 23·4 oxide of lime, 8·5 SO_3, 4·1 silica; and even from these figures we can learn that (unlike its congener, the Groundsel) its roots are infested by fungi, and that it absorbs no nitrates from the soil. Some biennials and perennials grow very rapidly in early spring, but the Ragwort is in no hurry, and flowers only in late July. The analysis also shows that it produces acids and resins rather than tannins; that is to say, its powers of deässimilation (oxidation) are limited; and there is also a tendency towards decomposition, as the presence of alkaloids or bitter principles evinces. The comparatively large dimensions and rigid posture of this plant indicate a great hold of water, which in turn depends on the great absorption of salts from the soil (the whole plant contains 23·3 per cent. pure ash, according to Anderson), and an active transpiration of water vapour from the leaves, whose form and configuration are eminently adapted to the purpose. The type of root here is eminently fitted to absorb nourishing juices from the soil, and the leaves have a delicate cuticle, and are destitute of every protection against excessive evaporation. The superior colorific faculty of the plant is evinced by the beautiful carmine-red tint which paints the epidermis of the lower portions of the stem.

The Marsh Cinquefoil (*Potentilla Comarum*), a tenant of marshes and the peat bog of mountains and meadow moors, may be taken as a type of the plants enrolled in the renowned order Rosaceae. It shuns a lime locality, and prefers a sandy one. Long roots spring from the stem, creep in the mud of pools and marshy places, and are surrounded by a thick spongy mantle of thin-walled cells with broad intercellular air-passages, serving a supply of oxygen to these parts; no lignin, or true cork, is developed there. Moreover, the roots are infested by fungi (*Mycorrhiza*), which means that the plant is nourished by the organic nitrogenous matter of the soil, and contains no nitrates; hence also it grows rather slowly. Like most of the Rosaceae, it is a pretty strong chemical plant, and its beautifully shaped leaves contain a good supply of carotin, wax, a crystalline hydrocarbon, and some fat-oil in the greener parts. As usual, also, a very notable amount of tannoid and tannin, precipitating gelatine, and tartar emetic are found. Not much free sugar, but large quantities of starch (especially at high noon), mucilage, pararabin, and oxalate of calcium are manufactured and stored up by the leaves. The ash of the overground parts yielded very little silica, and comparatively little phosphorus or sulphur (as befits a water-plant), but a large quantity of lime, iron, and manganese. The above analysis indicates immediately the powerful physiological activities of this type of rosaceous plant. Intense assimilation or chlorophyllian energy is attested by the abundance of starch and fatty matters, while the liberal outcome of tannin and acids (there is about twenty-four per cent. carbonic acid in the ash) prove that the process of deässimilation (oxidation) is specially vigorous and complete. Moreover, the latter progresses near to perfection, for it is observed that the

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inner segments of the calyx, the petals, stamens, and styles are always suffused with a dark purple coloration, whence the plant has earned the designation of the " purple-wort." Most other wild rosacean plants, such as Burnet, Lady's Mantle, Avens, Tormentil, and so on, contain chemical constituents very similar to those just reviewed.

The beautiful " Empress of the Lake " and the " Delight of the Waters " — the white Water-lily (*Nymphaea alba*)— has been thoroughly well studied as regards its morphology and internal anatomy, but the chemical outcome of its marvellous mode of life has been almost completely neglected. There are no cells with hard, thick walls (sclerenchyma) in the leaves or petioles, and their vascular bundles are arranged like those of the Monocotyledons, and with an extreme reduction of their woody portion (xylem), which is characteristic of water plants. Moreover, there are numerous empty air-spaces and canals, but no actual vessels fit for conducting sap. An examination of the leaves shows that they contain much wax, fat-oil, and carotin, but little chlorophyll and some resin ; there is a moderate quantity of tannoid, and a tannin which is rare in nature, and is known as gallotannin. Its presence in a plant is a clear indication of considerable oxidising agencies operative therein ; it is perhaps also indicative of a no great amount of lignification being required for that particular species or organ wherein it exists. There is a moderate quantity of sugars (glucose and levulose), an enormous amount of a specially slimy mucilage, and a quite unusual amount of reserve starch, along with some pararabin and a crystalline substance, soluble in dilute acids, which is oxalate of calcium, connected with an undefined pectic substance encrusting the walls of the intercellular canals and stellate cells of the petioles and blades. The rhizome may be four inches thick, is spongy, horizontal, dark brown, and emits a great number of long, white, nourishing roots and rootlets, which have no root-hairs : it consists of a dense outer wall, a cortex full of large air-spaces, and a central core traversed in all directions by vascular bundles. The petioles and peduncles which spring from it may be up to over nineteen feet long. It prefers a peaty bottom, and requires a large amount of nitrates, rather than ammonia, as food; a fact which would serve to explain its presence in certain waters and its absence from others. The rhizome contains about four per cent. fat and resin, ten per cent. tannin and its decomposition products, 6·25 per cent. sugars, twenty per cent. starch, four per cent. proteid matter, 23·6 per cent. crude fibre, and 5·5 per cent. ash. There is an ill-defined, harmless alkaloid in all parts of the plant, except the seeds, strange to say. It will be gathered from the foregoing that the Water-lily is exceptionally rich in starch (even the seeds contain forty-seven per cent. thereof); a fact which indicates an exceptional activity and plasticity of the protoplasm in connection more especially, perhaps, with the function of transpiration and growth. In fact, the enormous force requisite to project the petioles and peduncles to the surface from several feet depth of water, not to mention the hauling back of the flower again to near the bottom where the seed ripens—all this must require immense food stimulus and factor, and an extraordinary adaptation of form and tissue to function. It appears, however, that in this case the oxygen of the air, and also of the water, imparts to the cells an activity whence they derive a power of action beyond the influence of free oxygen in a manner and to a degree quite unusual in ordinary land plants. In fact, the amount of proteids in the tissues and of phosphates and sulphates in the ash of all parts is relatively very small, and there are no nitrates in the foliar organs. Thus by dint of chemical science we arrive at certain physiological conclusions quite contrary to those suggested by mere anatomy or class relationship.

That remarkable plant, known as Good King Henry (*Chenopodium Bonus-Henricus*), that dogs the footsteps of humanity may now be considered. It keeps severely to such stations as the roadsides and waste places near dwellings or ruins, and sometimes sheepfolds. The root and most of the stem have an abnormal structure, owing to a too small thickening growth. All these peculiarities of habitat, and so on, would be hopelessly inexplicable if no resort was made to chemistry. The analysis reveals a vast richness in chlorophyll and carotin, a great accumulation of mucilage, much resin and salts of organic acids, but very little tannic matter or free sugar, and no reserve starch. It is, moreover, especially a strong nitrate plant; a circumstance which ensures to it a great root-development, a rapidity of growth, a vegetative apparatus out of proportion to the reproductive capacity, and a sort of inevitable choice or selection of habitats where nitrogenous matters of a certain constitution only, and fitted to yield abundant nitrates to the roots, are specially produced and readily available.

CORRESPONDENCE.

A SWALLOW-TAILED BUTTERFLY.

To the Editors of " KNOWLEDGE."

SIRS,—On September 25th my gardener called my wife's attention to a very large black butterfly flitting about the garden. The appearance and size of it were so remarkable that my wife at first took it to be a bat. She called out to me, but before I could get to her it had flown away. The next morning it came again in the same part of the garden, evidently attracted by a bed of verbenas. It settled once or twice upon the flowers, but it was difficult to observe carefully, as even when it settled on a flower its forewings were in a constant state of fluttering. However, I could now see that it was a large black swallow-tailed butterfly. It was larger than the flower of a begonia near by ; and I afterwards measured the begonia, and found it nearly four inches across ; so that, if the wings of the butterfly had been spread out, it would probably have measured four or five inches across. I think it had some blue with the black on the upper side of its wings. Its back wings had a semicircular outline with tails, each about one inch long. My wife and I saw it again in the afternoon, but we had no net, and therefore could not catch it. It is evidently a tropical butterfly, and I am afraid we shall not see it again, as the bad weather has set in.

Can any of your entomological readers identify it from my rough description, and explain its presence in this part of the world ?

E. G. B. BARLOW.

" DITTON LODGE,"
STOURWOOD,
BOURNEMOUTH.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

PROFESSOR H. N. RUSSELL'S THEORY OF STAR-EVOLUTION.—I have alluded to this theory more than once in these Notes. But it is of such fundamental importance that it needs to be dealt with pretty fully. There was an animated debate upon it at the recent meeting of the British Association at Manchester. We may divide Professor Russell's results into two parts. The first is fairly certain. He utilises every scrap of evidence within our reach, direct or indirect, of the distances of particular stars, and from the figures adopted he deduces their absolute magnitudes, that is, their magnitude viewed at some standard distance, generally taken as ten parsecs, or thirty-two and a half light-years. He finds that all the stars of spectral type B are very luminous; while, as we travel along the range of spectral type towards M, the stars divide themselves into two groups, which get gradually wider and wider apart, so that when we get to types K and M the difference is obvious at a glance, the two classes of stars being designated as "giants" and "dwarfs." The giants of all the spectral types are of absolute magnitude −1, or thereabouts; while the dwarfs of type M are of absolute magnitude +9, a range of ten magnitudes, which means a ten-thousandfold diminution in the light that they emit. We may take it as established that there are these two sharply defined classes of red stars: the giant class, enormous bodies of small density and relatively low temperature, but giving a great deal of light, owing to their mass being spread out over such a large space; the dwarfs, of the same temperature as the giants, as is concluded by their identity of colour and spectrum, but having a much smaller radiating surface, presumably owing to their matter being greatly concentrated and their density high. So far the conclusions are not open to much dispute. This begins at the next stage, in which Professor Russell goes on to formulate a cosmic hypothesis to account for the facts. He supposes that stars are condensing throughout their career, beginning as diffused nebulosity at a fairly low temperature. As they condense they grow hotter, and at last shine with a red light as giant red stars. Still condensing, they pass through the K and the G types of spectrum. If their mass is above the average, their temperature will go on rising till they reach the B or helium type of spectrum. These stars are agreed to be the hottest of all, and of unusually large mass. If the stars be of lesser mass, they will reach their maximum temperature while of spectral type A, F, or even G. They will then commence to grow cooler, still continuing to contract, and will pass through the types in the order in which they are generally arranged, that is, BAFGKM; but they are now dwarfs. From the combined causes of diminished size and lowered temperature they give much less light than before. Since the same star is thus successively ranked as a giant and a dwarf, it is clear that the names are intended to refer only to its light-giving power, not to its absolute mass. The red dwarf stars are supposed to be nearing the end of their career as suns. Their surface gives a dull red glow, and presumably the crust-forming stage is not far off, if, indeed, it has not actually been reached in the case of the numerous variables that belong to this class. Professor Russell was not the first to enunciate the idea that the stars are divided into two classes—those whose temperatures are rising and falling respectively. Sir J. Norman Lockyer had reached the same conclusion from an analysis of the various spectra, combined with laboratory experiments conducted both with the comparatively low temperature of the electric arc and the higher one of the spark. Though he agreed with Professor Russell in the main fact, he differed greatly from him in the stars whose temperatures were supposed to be on the up and down grade respectively. Thus Lockyer put Capella, Arcturus, Canopus, Beta Cygni in the descending series, which involves the assumption that their density has become considerable; and, as their surface luminosity is obviously not very high, we have to give them great dimensions and enormous mass. The new views make them young orbs instead of old ones; and, as their density is supposed to be very small, there is no need to postulate masses exceeding that of the Sun a thousandfold. Now we have no evidence of the existence of such enormous masses among the stars. The evidence points to some such figure as thirty or forty times the Sun's mass as the maximum, and perhaps one-tenth of the Sun's mass as a minimum. The reason ot the latter limit is that a body of smaller mass would not attain a sufficiently high degree of incandescence to be seen at stellar distances. Another fact which receives an explanation on Professor Russell's hypothesis is that the fainter components of binaries are frequently bluer than the primaries. This was felt to be a difficulty, for the smaller component would pass more rapidly through the different stages, whereas the blue stage was taken as coming before the red or orange one. But on the new view the blue giant stage follows the red or orange giant stage, and the difficulty vanishes.

There is admitted to be a very strong case for Professor Russell's view, but difficulties are seen in some directions.

(1) Some spectroscopists are unwilling to admit that bodies at enormously different density can give identical spectra. It is answered that the fact has been demonstrated by actual cases. Thus the Astronomer Royal quotes two stars of type M, Antares and Groombridge 34, the former having a density of the order of 1/10000 of the Sun, the latter probably greater than the Sun. Professor Eddington quotes three eclipsing variables with the same spectrum as the Sun (type G), but density less than air; while that of the Sun is greater than water.

(2) Another difficulty urged by Professor Fowler is that the spectra can be arranged in a continuous series from nebulae through the Wolf-Rayet stars (type O), thence in the familiar order BAFGKM. The place of the nebulae is felt to be a difficulty on Russell's theory.

(3) A third difficulty is alluded to both by Professors Fowler and Eddington. The study of stellar velocities has shown that these follow the spectral types in the familiar order, BAFGKM. Both giant and dwarf M stars have high velocities, while the B stars have small ones. Now we can see no reason why a star should lose velocity while its temperature is rising, and regain it when the temperature falls again. The planetary nebulae have still higher speeds than the M stars, and it is very difficult to know where to place them in a scheme of cosmogony.

The formation of cosmogonic schemes is the hardest task essayed by the astronomer, and it is never wise to adopt any scheme as absolutely final. But it is generally admitted that Professor Russell has made important contributions to our knowledge, though probably his scheme will need some revision before it corresponds with all the known facts. I may remark incidentally that Father Cortie gives a useful mnemonic for remembering the sequence, OBAFGKMN. The words, "so baffling," give the first four letters in their right order, and the others offer less difficulty. He also speaks in favour of retaining the Secchi classification (types I, II, III, IV, V), as well as the Draper one. I hardly think that this will meet with favour, as the tendency is to simplify notation.

COMETS.—Mr. Mellish has discovered two comets in the present year, the second being found on September 13th.

XUM

The following orbit has been calculated by Messrs. Einarsson and Alter from observations on September 18th, 20th, and 21st: Perihelion Passage, 1913, October 13th, noon; Omega 115° 44′, Node 76° 1′, Inclination 51° 59′; Log. q., 9·6712; November 6th, R.A. 15h. 49m.; South Declination 24°; November 14th, R.A. 16h. 23m.; South Declination 30°. The comet will be an evening star in November, and better placed for southern than for northern observers.

BOTANY.

By PROFESSOR F. CAVERS, D.Sc., F.L.S.

RELATIONSHIPS OF "AMENTIFERAE."—The affinities of the catkin-bearing Dicotyledons, or "Amentiferae," have been frequently discussed; but, until recently, there has been a fairly general agreement as to their being a primitive group. On the other hand, there are strong reasons for the belief that the cohort Ranales, including the tulip tree, buttercup, and other families, is a primitive group. Various writers on the evolution of the flowering plants have constructed schemes of descent embodying both of these views, thus deriving the higher flowering plants (Angiosperms) from two distinct sources at least. Miss Berridge (*Ann. of Bot.*, Vol. XXVIII) has investigated the structure of the flower in *Castanopsis chrysophylla*, the Californian golden-leaved chestnut, which, from the fact that it possesses flowers that are structurally bisexual, though functionally female, seemed likely to prove interesting on comparison with the more reduced forms in the Fagaceae. From her observations, and a review of the literature of the subject, she concludes that there is nothing in the structure of the flower of the Fagaceae to preclude the view that the family is derived from some rather primitive Angiospermic stock, possessing bisexual (hermaphrodite) flowers with syncarpous multilocular ovaries, and that the ancestral flowers may also have had a double perianth, the parts in fives and the ovary inferior. These features, as well as the large number of characteristics common to the Fagaceae and Rosaceae, seem to point to ancestors allied to some of the epigynous types among the Rosales. Two of the most marked features which separate the Fagaceae from the higher orders—the trimerous nature of the flower and the form of the inflorescence—are shown to be probably the result of a strong tendency in the family to aggregation of the flowers, and to economy in the parts of the individual flower. The cupule is regarded as consisting, not of bracts, as generally supposed, but as having arisen by modification of certain branches of the inflorescence.

THE SOIL SOLUTION.—The physical factors which determine the growth and distribution of plants are broadly divided into two categories, climatic (atmospheric) and edaphic (soil) factors. With the advance of plant ecology from a mere superficial study of the distribution of species, and the drawing up of lists of plant communities to a thorough correlation between the characters and distribution of plants on one hand, and the factors of their environment on the other, detailed studies are being made of the various factors. It is already apparent that much of the older work on the relation between plant distribution and soil characters has been erroneous, and that there is very little, if anything, in the idea that the chemical composition of the soil is the chief, or even an important, factor in determining plant distribution. More stress is now laid on the physical characters of soils, and also upon the extraordinarily varied and important organic micropopulation of the soil. Several important papers have been published recently on the soil solution, *i.e.*, the water of the soil, or the salt solution with which the roots of plants are in contact, and from which they absorb the minerals required for nutrition. Stiles and Jörgensen (*Journal of Ecology*, Vol. II), in an important paper, describe and discuss the various methods that have been used for obtaining this solution from the soil itself. This is by no means so simple a matter as might at first sight appear. For instance, much reliance has been placed on the analysis of drainage water from agricultural soils; but it is pointed out that this water passes through the spaces between the soil particles and their water-films, and scarcely comes into contact with the particles themselves, while drainage from the films of dissolved substances will necessarily be a slow process. Hence the drainage water is not representative of the water surrounding the soil particles. The same arguments hold against the lysimetric method of pouring a gentle current of water through soil samples, and collecting what drains through. It is very doubtful to what extent the latter actually represents the water present in the soil, which is supposed by this method to have been displaced by the water percolating from above. Similarly with the other methods described. The soil is a very much more complex thing than has hitherto been realised, and much of this complexity may be attributed to the presence of colloidal substances, the relations between which and the crystalloids present must be affected by the various extraction methods. The importance of colloids in influencing the composition of the soil solution has been shown by Gola's work, an account of which appears in the same number of the *Journal of Ecology* (Vol. II, No. 4). The work of this Italian botanist, published between 1905 and 1912, had apparently been almost entirely overlooked, despite its important bearing upon plant ecology and economic botany. Gola's main idea is that the relations between plants and soils are chiefly determined by the concentration of the soil solution, and the limits between which this may vary, and that these are in turn controlled by the contrasting characters of the colloidal and crystalloidal constituents of the soil. The paper gives a summary of what is known regarding the colloids of soils, and Gola's system of classification of plant communities is outlined. The main division is into "haloid" and "geloid" types of soil, *i.e.*, into soils with solutions dominated respectively by crystalloidal and colloidal substances, the additional terms, "perhaloid" and "pergeloid," being used where these contrasting constituents become very pronounced. Each type is again divided according to whether the concentration of the soil solution is relatively stable and constant, or unstable, and liable to vary within wide limits. The four main types of vegetation—water plants, marsh plants, mesophytes, and xerophytes—thus fall into thirty-two groups in all, each characterised by a more or less distinctive flora of its own, though, of course, a good many plants fall into two or more of these divisions. For details of this interesting and important contribution to ecology reference should be made to the paper itself; but it is clear that it is by means of work of this kind—careful analysis of the various factors of the environment—that progress is being, and will be, made in this branch of botany, and that the ideas expressed by such terms as "calcicolous," "calcifuge," and the like, applied to plants growing in, or avoiding, soils containing lime or other chemical substances, must be discarded with the growth of knowledge about the soil.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

SYNTHESIS OF AMMONIA.—An abstract of a communication by Messrs. Haber and Greenwood in the *Zeit. Electrochem.* is published in *The Journal Chemical Society*, 1915, CVIII, 443. It has already been shown by Haber and Rossignol that by passing a mixture of hydrogen and nitrogen over uranium containing carbon the metal absorbs part of the nitrogen, while at the same time acting catalytically and causing the hydrogen to combine with more of the nitrogen to form ammonia. It has now been found that by passing the mixed gases under a high pressure over uranium carbide at a temperature of about 500° C. uranium nitride is formed and this is soluble, for the most part, in acids with the liberation of ammonia. The small portion that is undissolved by acids is decomposed by concentrated

boiling alkali. As the formation of the uranium nitride proceeds the material crumbles to powder, and eventually, after a long time, is left as a hard, compact mass, with a pronounced catalytic action. The rate of formation of the nitride shows an increase with the increase in the pressure applied to the gases.

SOURCES OF POTASH.—The scarcity of potassium salts in America, due to the stoppage of the German supplies, has led to the investigation of the possible native sources of supply. Mr. E. Hart, writing in *The Journal Ind. Eng. Chem.* (1915, VII, 670), considers that before long a considerable quantity of potash will be obtained by condensing the fumes from cement kilns. For example, a sample of the material thus recovered was found to consist of ninety-four per cent. of potassium sulphate and five per cent. of potassium carbonate.

He also points out that, while it would not be profitable to use high-grade felspar as a source of potash, large quantities of a lower grade are obtainable and suitable for the purpose. A factory is now being built in Tennessee for treating such material by heating it with barytes in a reducing atmosphere. In the reaction a silicate of barium, aluminium, and potassium containing about thirty-six per cent. of silica is produced. This is fused, run into water, and ground up, and afterwards treated with the calculated quantity of sulphuric acid. On evaporating and crystallising the solution, alum, free from iron, and aluminium sulphate of good quality are obtained. The white residue left from the acid treatment consists of a mixture of barium sulphate and silica, which could be utilised in the preparation of paper for printing and as a pigment for printing inks.

According to Mr. O. C. Roberts (*Chem. News*, 1915, CXII, 81), attempts on a large scale are being made at Dulacca, Western Australia, to destroy the prickly pear, with which the ground has become infested, and to recover the potash in the ashes. The trees are first destroyed by means of arsenious chloride and then burned, and it is stated that the quantity of wood ashes, containing fifteen per cent. of potash, has reached seven tons per acre. Some ten thousand acres of the infested land are now being treated in this way, and it is anticipated that before long considerable quantities of potash from this source will be available.

GEOGRAPHY.

By ALEXANDER SCOTT, M.A., B.Sc.

EXPLORATION IN THE KARAKORAM.—In the August *Geographical Journal* Dr. Filippi gives an account of his journey in the Eastern Karakoram during 1913–14. The expedition, which was magnificently organised, both as regards equipment and personnel, explored parts of the Upper Indus and Shyok Valleys, and the Remo glacier (on the Depsang plateau), and then proceeded over the Karakoram Pass to the valley of the Yarkand, finally reaching Kashgar. The Remo glacier proved unusually interesting, as it differs from the usual Himalayan glacier in having several outlets. Not only does it drain southwards to the Shyok, a tributary of the Indus, but it also has an outlet, on the Asiatic side, to the Yarkand, of which river, indeed, it is the source. Another remarkable feature in the Remo glacier is the absence of morainic material. The mountains of the Eastern Karakoram differ physically from those further west, and also from the Himalayas proper, in possessing neither colossal precipices nor deep valleys, such as are common in Sikkim. The hills never rise conspicuously, but are covered with débris, which may be accounted for by the absence of great agencies of transportation and by the softer types of country rock (cf. *Nature*, October 7th, 1915).

ORIGIN OF ALPINE LAKES.—In a paper in *The Geological Magazine* (August, 1915) Preller discusses the origin of the smaller Swiss lakes. Those which have moraine barriers have obviously been formed during the last retreat of the ice, a mode of formation already deduced for the larger lakes (cf. "KNOWLEDGE," July, 1915), while several whose barriers are composed of fluviatile material, are of Post-glacial origin. Some, which lie along the contact of the Jura and Molasse, originated in late Glacial times, and have been further banked up by alluvium. The diminution in the size of the lakes is due, not to a decreased precipitation, but to an increased amount of percolation and evaporation.

In a further paper (*Geol. Mag.*, September, 1915) the same author considers the lake systems of Northern Italy. The great moraine barriers which occur at the outlets of the valleys along the southern fringe of the Alps have numerous marine shells embedded in them, pointing to an extension of the Adriatic Sea, in late Pliocene and early Pleistocene times, as far as the lake basins; further, the double and triple concentric moraines indicate a long stationary period in the ice-retreat. The formation of the lakes is ascribed to a flexuring and subsidence along the base of the Alps, which, occurring simultaneously with the recession of the sea, converted the fiords into lakes, the process being completed by the operation of the moraine barriers. The great depth of the lakes is not to be explained by over-deepening, due to glacial erosion, but arises directly from the comparatively intense folding.

ORIGIN OF KAMES.—Some confusion seems to exist in geographical and geological literature concerning the definition of the terms "kame" and "esker." In 1912 (*Geog. Journ.*, Vol. XL) J. W. Gregory defined the former as "fluvioglacial or glacieluvial deposits along the margin of a receding ice-sheet or glacier," and the latter as "ridges deposited at the mouths of glacial rivers discharging from a receding ice-sheet." In *The Scottish Geographical Journal* (September, 1915) the same writer describes in detail the well-known kames of Carstairs, and discusses their origin. The transverse banding which characterises the Swedish eskers is absent, while the kames are obversely transverse to the main glacial drainage lines. There seems little doubt that they were deposited by the floods, caused by the melting of ice, and the nature of the included boulders suggests that the source of the ice was two glaciers, coming from the west and south-west, that is, from the Southern Uplands. The explanation likewise accounts satisfactorily for the irregular, confluent ridges of the kames. The smaller kames at the foot of the Tinto Hills are obviously of glacieluvial origin, as the boulders are characteristically subangular.

GEOLOGY.

By G. W. TYRRELL, F.G.S., A.R.C.S.

SCANDINAVIAN DRIFT OF THE DURHAM COAST.—An interesting record of one of the earliest, if not the earliest, ice invasions of the east coast of England has been discovered by Mr. C. Taylor Trechmann at Warren House Gill, on the Durham coast (*Quarterly Journal Geological Society*, September, 1915). This consists of a bed of shelly clay, which has been preserved in a pre-Glacial hollow of the Magnesian Limestone, near the centre of which is a fissure eighty or ninety feet wide and of uncertain depth. The material is a dark, tenacious clay, containing shells of unmistakable Arctic affinities. It also contains numerous boulders, some of which are firmly calcreted (cemented by deposited calcium carbonate) into the subjacent Magnesian Limestone. Up to the present none of the ordinary erratics from the north of England or Scotland, which occur abundantly in the overlying Cheviot Drift, have been found in this shelly clay. Its boulders are probably all Scandinavian in origin, although further comparative petrographical work might possibly disclose other sources. The position of this drift and its contents indicate an early invasion of an ice-sheet from the direction of the North Sea, carrying Scandinavian boulders. This sheet attained its maximum extension before the local ice flowing from north and west had reached the east coast. In the ensuing discussion of

Mr. Trechmann's paper Mr. G. W. Lamplugh supported the correlation of this Scandinavian drift with the shelly basement boulder clay of Yorkshire.

ANDALUSITE IN CRETACEOUS AND EOCENE SANDS.—Mr. G. M. Davies has brought together evidence to show that the mineral andalusite is a frequent constituent of the Eocene and Cretaceous beds of the south-east of England (*Mineralogical Magazine*, September, 1915). He has found it in many sands of the Eocene, in the Folkstone beds, the Lower Greensand sponge gravel of Faringdon, and also in a sand of Wealden age from Shotover Hill, near Oxford. Andalusite is a comparatively unstable mineral, and it was thought that it could not survive in an unaltered state in sands older than the Pliocene. Dr. Davies' observations, however, show that andalusite may occur in beds as old as the Wealden, and it is therefore unnecessary to assume excessive instability for this mineral. Furthermore the presence of abundant andalusite in a sand is not necessarily evidence of its comparatively recent age.

THE ESSEXITE OF CRAWFORDJOHN (LANARKSHIRE).—This well-known and beautiful rock is described by Mr. A. Scott in the October *Geological Magazine*. It contains large black augite crystals embedded in a grey ground-mass, and when polished forms a very handsome stone. On account of its toughness and freedom from cracks, it has been much used in the past for the manufacture of curling stones, although the riebeckite-microgranite (" Blue Hone") of Ailsa Craig has always been the favourite stone for this sport. Specimens of the Crawfordjohn essexite have been previously described by Teall and Lacroix, but the whole occurrence is now exhaustively described by Mr. Scott, who gives details of its chemical and mineral composition, and of its geological relations. Mineralogically, it consists essentially of plagioclase felspar, with fresh olivine, and abundant large crystals of purple titanaugite. Ilmenite and apatite are fairly abundant, and the interstices are filled with nepheline and analcite. It occurs as an elongated boss intruded into Ordovician sediments, and was formerly regarded as belonging to one of the great north-west to south-east Tertiary dykes. Mr. Scott, however, shows that it is entirely independent of these. In all probability it is an outlying member of the Carboniferous-Permian alkaline series of Ayrshire (see " KNOWLEDGE," 1912, page 342), as an exactly similar rock is intrusive into one of the Permian volcanic vents of that area.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.MET.SOC.

THE WEATHER OF NOVEMBER.—November is generally thought to be a very dreary month, and, with few exceptions, the atmosphere is for the most part unsettled, gloomy, and damp. The south-west wind is prevalent, and heavy gales may occur. A sudden decrease of temperature may at any time be expected, with sharp frosts and slight falls of snow; but very severe frosts seldom commence till the last week, and are not usually of long continuance. It was a very mild month in the years 1847, 1881, 1888, 1894, 1895, 1899, 1906, 1908, and 1913. It was very cold in 1851, 1858, 1862, 1871, 1878, 1879, and 1910.

The mean temperature at Greenwich for November is 43°·5; in 1852 and 1881 it was as high as 49°·0, while in 1871 it was as low as 37°·4. The average maximum temperature is 49°·0; the highest mean was 54°·5 in 1852, and the lowest 43°·2 in 1871. The average minimum temperature is 37°·9; the highest mean was 44°·1 in 1852, and the lowest 32°·4 in 1851 and 1910. The absolute highest temperature was 67°·3 on the 8th in 1847, and the absolute lowest 18°·3 on the 28th in 1890.

The average rainfall for November is 2·29-in.; the greatest amount was 6·00-in. in 1852, and the least 0·42-in. in 1867. The heaviest fall in one day was 1·29-in. on the 13th in 1861. The average number of " rain days " (*i.e.*, days on which 0·01-in. fell) is 14·0; the greatest number of days was twenty-four in 1872, and the least five in 1867. November is generally considered to be the month with the greatest number of fogs.

The average amount of bright sunshine at the Kew Observatory, Richmond, is fifty-one hours, or twenty per cent. of the possible duration. The average barometric pressure in London for November is 29·907-in.; the highest mean was 30·337-in. in 1805, and the lowest mean was 29·537-in. in 1810.

DISCONTINUITIES IN METEOROLOGICAL PHENOMENA.—At the meeting of the Royal Meteorological Society on June 16th Professor H. H. Turner, F.R.S., gave an account of an investigation upon which he has been engaged for some years, and which has recently assumed a new character, in which it promises results of immediate interest to meteorologists. He finds that meteorological history is divided into " chapters," averaging six and one-third years long, with abrupt changes (or " discontinuities," as he calls them) between. The dates of change are apparently settled by the movement of the Earth's axis. They oscillate about mean positions in a cycle of 40·5 years, which appears in Brückner's collected " cold winters " for eight hundred years; in Nile flood records for one thousand years; and in measures of Californian tree rings for five hundred and twenty years. The " chapters " are alternately hot and cold, wet and dry, as shown by rainfall and temperature records at Greenwich, Padua, and Adelaide.

AUDIBILITY OF DISTANT THUNDER.—If we count the number of seconds between the time of seeing a flash of lightning and of hearing the thunder, we can estimate the distance of the thunderstorm, because lightning is seen instantaneously, while the sound of thunder travels at a definite rate. An interval of about five seconds would indicate that the flash is a mile away. As a rule, thunder is not heard at a greater distance than at about twelve or fifteen miles. In *Symons's Meteorological Magazine* Mr. Harold Wilson reports that on August 1st he saw two flashes of lightning in the west-north-west, and only heard the thunder after intervals of one hundred and fifteen and one hundred and twelve seconds respectively. He calculates that the distance of the first flash of lightning would be 24·4 miles, and of the second flash 23·8 miles. Professor Alexander S. Herschel, F.R.S., recorded in *The Quarterly Journal of the Royal Meteorological Society* (Volume XIV, page 222) an instance, on February 13th, 1888, on which he heard thunder at a distance of about forty-four miles from the flash of lightning.

HEAVY RAINFALL IN JAMAICA, JUNE, 1915.—Mr. Maxwell Hall, the Government Meteorologist, in *The Jamaica Weather Report* for June says that heavy rains fell over the east and the middle of the island between the 14th and the 18th, due to a storm-centre, at first west, and then north-west of Jamaica, which drew in the winds from the south-east and the south. On the 15th about five inches fell in Kingston and its neighbourhood. Early in the morning of the 18th a great rain-storm, with thunder and lightning, passed over Kingston and lower St. Andrew; and between the 14th and the 18th over thirteen inches fell. In the country districts some damage was done to the roads. The rains at Hartlands on the 15th afford a case of a marked maximum at a particular place during heavy general rains. On the 15th, between 7 a.m. and 6 p.m., nine inches fell; and between 6 p.m. and 7 a.m. the following morning 4·40-in. fell; so that 13·40-in. were registered for the 15th.

PREVENTING FOG WITH OIL.—The United States Hydrographic Office on the *Pilot Charts* for November calls attention to the possible value of oil as a preventive of fog at sea. It is reported that experiments have been made in France with variable success to prevent the fogs in river valleys, the best results being obtained by employing

vegetable oils. This covered the surface with a thin film of oil, which kept the air from coming in direct contact with the warmer water, and thus hindered the condensation of the water vapour. It may well be that a ship which has to stop or anchor off a fog-bound coast can create a clear zone around her by distributing storm oil for a time. The Hydrographic Office would be glad to hear from those who make the experiment, and from any who may already have had experience in this line. Careful note should be made of all the conditions, such as the character of the fog, temperature of air, temperature of sea-water at surface, state of the sea, direction and force of the wind, method of employing oil, kind and amount of oil used, and how much headway, if any, the ship had; then report whether the oil appeared to spread well, how long it was applied, and what effect it had on the fog.

MICROSCOPY.

By F.R.M.S.

THE MICROSCOPE FINE ADJUSTMENT.—In the choice of a microscope, the amateur too often neglects to ascertain the efficiency of the fine adjustment when working with really high powers. In some medical schools, where the matter is entrusted to the lecturer, the same holds good, and microscopes of an old and once excellent pattern are still recommended, though entirely out of date and utterly unsuitable.

Two years ago Professor Minot, of Harvard, called upon me, and together we discussed a few points about the modern microscope. "Do you know the —— microscopes?" he asked. I told him I did. "And what do you think of them?" he said. I answered, "Excellent, except that the fine adjustment is not good enough for oil-immersions." "You are quite right," he said. "I told them so only a few months ago, and they are altering their pattern." And altered these microscopes are, though even yet not quite perfect, in my own opinion.

The first point to test is whether there is any backlash or loss of time in the movement. As a matter of fact, this is seldom found, as most microscope makers obviate all chance of this by means of a counter spring, which in most cases acts admirably. Only in old and second-hand instruments is this defect sometimes to be detected, and a new spring soon puts it right. Any side movement can also usually be corrected by tightening the screws of the slide, or in some cases by a drop or two of good sperm oil or oil of sweet almonds on the movement, wiping off all superfluous oil with a clean linen cloth. Usually it is only apparent with the highest powers. But it should not exist at all, and indicates soft metal or great age, or both.

Roughly speaking, fine adjustments fall into two classes: those acting directly with a screw and those having in addition a lever or cam, or some intermediate method of diminishing the motion of the screw.

In the first class the threads of the screw are almost invariably half a millimetre (one-fiftieth of an inch) in pitch. Thus one whole revolution of the screw gives a movement of half a millimetre. This acts very well for all objectives up to four millimetres (one-sixth inch) in focus, and up to about ·65 in angular aperture. Such a lens, with the highest eyepiece in common use, gives a magnification of about 600. Most observers will not use it for a magnification of more than 400, but the image is hardly impaired even at the higher figure. Such an objective will work through any thickness of cover within reason, and needs neither collar correction nor any alteration in length of the draw tube for varying thickness of covers.

When, however, we substitute an objective of the same focal length, but with an aperture of ·85, we find that this make of fine adjustment breaks down, and is scarcely sensitive enough. One maker at least obviates this difficulty by making his screw one-third of a millimetre in pitch; but even then it breaks down with objectives of three millimetres and still more with a 2·5 millimetre, the highest dry-power objective in common use for bacteriology. For oil-immersions of the usual power and aperture, and still more for microphotography, this form of fine adjustment is utterly out of question.

So far we have spoken only of what experience teaches. It remains for us to deduce conclusions and state results, and apply them to higher powers.

Professor Abbe long ago demonstrated that the depth of focus (or depth of sharpness or penetration) was in inverse proportion to the product of the numerical aperture and the initial magnification of the objective.

Thus the depth of focus of the four-millimetre objective of N.A. ·65 would be

$$\frac{1}{\cdot 65 \times 40}$$

the latter being the initial magnification of the system with the one-hundred-and-sixty-millimetre tube.

Now let us proceed to the ordinary one-twelfth-inch oil-immersion of N.A. 1·30, which is most commonly used, and costs everywhere £5. It is in reality a one-fourteenth-inch, *i.e.*, 1·8 millimetre objective, and hence its initial magnification is $\frac{160}{1 \cdot 8}$, say ninety. Thus its depth of focus is $\frac{1}{1 \cdot 30 \times 90}$.

$$\cdot 65 \times 40 = 26.$$
$$1 \cdot 30 \times 90 = 117.$$

117 is to 26 as $4\frac{1}{2} \times 1$.

In order, therefore, to be perfectly efficient the fine adjustment for the 1·8 millimetre lens should be four and a half times as slow as one for the four-millimetre objective. In order to embrace oil-immersions of N.A. 1·4, we may change four and a half into five with advantage.

The four-millimetre objective requires a movement of ·5 millimetre per turn of the fine adjustment; the 1·8 millimetre would therefore require $\frac{\cdot 5}{5} = \cdot 1$ millimetre per turn.

It is objected that such a slow movement (one-two-hundred-and-fiftieth inch) is not a convenient one with medium powers, as it is difficult to decide which is the best focus. This difficulty, however, completely disappears with experience. The tyro may try the dodge of putting the image just out of focus; then turn the fine adjustment until it is equally out of focus the other way. Then turn the milled head just half the distance back, and the correct place will be found.

One maker gets over the difficulty in a very ingenious and efficient manner. A screw with a coarse thread works *inside* another with a thread five times as fine. The coarse thread moves the body about one-sixtieth inch per turn; the fine one, one-three-hundredth inch. We should have preferred one-half millimetre (one-fiftieth inch) and ·1 millimetre (one-two-hundred-and-fiftieth inch), but this is perhaps hypercritical. At any rate, the idea is a good one, and gives excellent results in practice. It shows also how well theory and practice agree.

E. ARDRON HUTTON, M.A.

PHOTOGRAPHY.

By EDGAR SENIOR.

CELLULOID AND ITS USE.—So much has been written of late concerning the use of cotton and wood pulp in the preparation of nitrocellulose to be employed in the making of propulsive explosives that it may be of interest to consider their further employment in the manufacture of celluloid, since the substance is composed of soluble nitrocellulose (having the composition approximately $C_{12}H_{16}[NO_2]_4O_{10}$) and camphor, the latter appearing to play the part of a solvent of the nitrocellulose. In the preparation of nitrocellulose finely divided cellulose, such as cotton-wool or certain kinds of paper, is steeped for a few minutes in a mixture of nitric and sulphuric acids,

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then squeezed, thoroughly washed, and dried, when it is found that a considerable increase in weight has occurred, and the substance has become highly explosive, taking fire at a temperature of about 149° C., and burning without any smoke or residue. This is pyroxylin, or gun-cotton. Celluloid, on the other hand, can only be ignited by direct contact with flame, when it burns with very great rapidity, but without explosive violence, and, at the same time, evolves thick fumes. The great danger of celluloid lies in the rapidity with which it continues to burn, rather than in any facility for spontaneous ignition. It cannot be kindled by shock, friction, or elevation of temperature to 150° C. The degree of inflammability has, however, been found to vary with the quality of the celluloid. Celluloid may thus be considered as a non-explosive derivative of nitrocellulose, softening when heated to from 80°–90° C., and regaining its rigidity on cooling, and it is this property which permits of its being readily moulded into various shapes. It has a specific gravity of 1·35. The word "celluloid" is registered as a trade-mark in the United States. The substance was first produced by Daniel Spill, of Hackney, and was introduced under the name of "xylonite." Considerable improvements, however, were made in the manufacture by John W. Hyatt, of Newark (New Jersey, U.S.A.), an American patent being granted to him in April, 1869. After this the United States soon became the centre of the new industry. In the preparation of the nitrocellulose, tissue paper is by preference employed, this being cut into strips, which are allowed to remain for about twenty minutes in a mixture of nitric and sulphuric acids, containing from nineteen to twenty per cent. of water, the solution being used at a temperature of not less than 30° C. To every one hundred parts of nitrocellulose taken forty parts of alcohol and thirty-five parts of camphor are added, and the whole thoroughly incorporated in a kneading machine. Owing to its plasticity when still containing a portion of its solvents, and the facility with which it may be coloured by means of coal-tar and other colouring matters, celluloid lends itself readily to the manufacture of imitations of a number of natural products, such as amber, tortoise-shell, marble, and so on, and considerable use is made of it in this way. Solutions of celluloid are also employed as a varnish or lacquer for coating objects, the varnish having the remarkable property of not imparting any gloss to surfaces which are unpolished; while, at the same time, all the lustre is preserved on surfaces which are polished, and on account of the extremely thin coating of varnish objects coated with it retain all their original flexibility. Celluloid varnishes are known by the names of "Zapon varnish," "Victoria lacquer," "Crystalline varnish," and so on. Celluloid may be regarded as completely insoluble in water, as prolonged immersion in hot water only dissolves out a very small quantity of the camphor. Sulphuric, nitric, or hydrochloric acid has little or no action in the cold at ordinary temperature. Glacial acetic acid, however, rapidly dissolves it; and if the solution is poured into a large quantity of water the nitrocellulose and camphor are precipitated. Alcohol of ninety per cent. strength causes the celluloid to swell and soften, and upon the application of heat decomposition occurs, owing to the solubility of the camphor in alcohol. Celluloid is readily soluble in acetone, sulphuric and acetic ether, amyl acetate, and in mixtures of these with alcohol. One of the best commercial solvents, however, appears to be camphorated alcohol, made by mixing ten parts of camphor with one hundred parts of alcohol, as this rapidly brings about solution.

USE OF CELLULOID IN PHOTOGRAPHY.—Celluloid on account of its transparency and flexibility has found considerable use in photography, as a support for the sensitive emulsion of silver bromide in gelatine. The first to suggest its use in this way was MM. David and Tailfer; while M. Planchon, of Lyons, was the first to manufacture such films commercially. The first plates made consisted of a sheet of celluloid held in a metal frame, which ensured their rigidity and prevented warping. At the present time, however, films are chiefly employed in long, thin sheets, which are wound upon a spool, and used in Kodak and similar cameras. In the manufacture of such films, collodion, viscose, celluloid, or the uninflammable cellulose acetates have been used. Celluloid, however, offers certain advantages with regard to flexibility, transparency, strength, and permanence in the presence of moisture, while it possesses the disadvantage of containing nitrated products and camphor, which are liable to affect the silver salts and to impair their sensitiveness. In the manufacture of celluloid films nitrocellulose made from cotton is usually employed, the celluloid solution in some cases being poured upon a glass plate and allowed to harden, after which it is stripped from the glass. This method, however, although simple, does not admit of the manufacture being carried out on a large scale, and on this account the plan most generally adopted is to run the solution out in a continuous manner upon an endless band having a forward motion, the film being dried in its course, the solvents being expelled under the influence of ventilation. The film is finally detached from the endless band, and taken to a drying chamber to harden thoroughly. As the endless band replaces the glass plate first mentioned, it must possess a well-polished surface.

NON-INFLAMMABLE FILMS.—The danger of ignition which attends the use of cellulose has led to research for other materials less susceptible to it, and chief among those proposed are films made of gelatine containing glycerine, pellicles of viscose, and cellulose acetate. The first and second are unsuitable owing to the action of water and various photographic solutions upon them. The cellulose acetates, primarily intended for use for all purposes for which celluloid is suitable, and, with the advantage of non-inflammability, produce a soft film which will not permit of their being employed in cases where hardness is an essential quality; and while the addition of camphor is found useful, a brittle product is the result of using it. Then, again, it is found necessary to have recourse to mordants when the material is required to be stained. The use of cellulose acetates has up to the present been almost entirely restricted to the manufacture of cinematograph films and papers in imitation of leather.

PHYSICS.

By J. H. VINCENT, M.A., D.Sc., A.R.C.Sc.

THE ELECTRIC SPARK.—A very interesting paper, by Sawtelle, on this subject appears in *The Astrophysical Journal* for September, 1915. As a preliminary to the study of the electric spark by spectroscopy, it was necessary to devise a method of controlling the time when the spark occurred to a very small fraction of a second. This is obtained by means of a beam of ultra-violet light reflected from a rotating mirror upon the negative terminal of a spark-gap, in series with the principal gap, the radiations from which are to be spectroscopically studied. Ionisation is thus effected, which, added to that produced by the electric field, is sufficient to cause the spark to pass if the potential of the charging device is sufficiently high; the ultra-violet light thus has a trigger action in letting the spark off at the precisely correct instant. The oscillatory character of the spark is strikingly shown in a number of very beautiful photographs, and the method is extended to enable spectrographs of the light from the central parts of the spark, and from the electrodes, to be taken separately, and studied with regard to the time at which the various types of radiation are emitted.

RADIO-TELEGRAPHIC INVESTIGATIONS. — From the report of the committee of the British Association appointed to carry on wireless research we gather that, in spite of the war, much good work has been done. Atmospheric disturbances, or "strays," are well known to all

operators, and the report gives some interesting information about them. The principal and most universal fact is that the strays heard in the dark hours are much more numerous than those heard during daylight. Occasionally the radio-telegraphic work at a station is rendered almost, or quite, impossible for a period by strays of vigour and number greatly exceeding the average. The periods of severe strays coincide with periods of low barometer, high-wind velocity, rapid change of temperature, great rainfall, and especially, rapid barometer fluctuations. Curiously enough, no correlation seems to exist between strays and the occurrence of auroral displays. The possibility of the use of strays in foretelling the weather is suggested by the fact that, in the case of the Australian station, rain in the daytime is nearly always preceded by intermittent disturbances.

A SINGULAR CASE OF CHROMATIC REFLECTION.—The remarkable colour effects exhibited by covellite (crystalline cupric sulphate) are described by Merwin in *The Journal of the Washington Academy of Sciences* for May 19th, 1915. When finely powdered and examined in daylight, it looks dark blue. Brilliant crystal surfaces are lighter, and vary in colour with differences in crystallographic section. In obliquely incident daylight a plate, parallel to the cleavage, immersed in alcohol appears brilliant purple; in benzene, reddish purple; and in methylene iodide, it appears red. Merwin investigated the optical properties of covellite, using artificially prepared crystals, and was able to explain these phenomena by taking account of the strong absorption and great dispersive power of the substance.

A SAFE METAL *X*-RAY TUBE.—The screens which limit the beam of *x* rays, and confine it within desired limits, are at present absolutely essential for the safety of the operator, and desirable also for the patient. Zehnder has recently designed a tube, which renders these protecting screens unnecessary. It is made almost entirely of brass, so that its walls form a screen, except where the rays are allowed to emerge through an aluminium window. The electrodes are introduced through porcelain plugs, suitably cemented to the body of the tube.

" WOLF " NOTES.—A " wolf " note is a note which a stringed instrument fails to produce properly when an attempt to play the note on the instrument is made. Such notes are met with in violins and 'cellos, especially in old and in inferior instruments. White (*Cambridge Phil. Soc. Proc.*, June, 1915), who has recently investigated the matter experimentally in the case of the 'cello, finds that the pitch of a wolf note coincides with that of best resonance for the belly of the instrument. From this it appears that, for the wolf note, the resonance is too perfect, and that a slower dissipation of the energy would produce a better effect from a musical standpoint.

FLUORESCENCE PRODUCED BY ULTRA-SCHUMANN RAYS.—In 1910 Professor R. W. Wood discovered a radiant emission from the electric spark which showed on further investigation that it consisted of waves of light of extremely short wave-length. No method was found of determining their wave-length. The radiation cannot be directly observed or photographed, but its existence is shown by the fluorescence which it caused in certain gases. The matter has recently been further investigated by Meyer and Wood. The radiation produced by a transformer spark is allowed to pass into a metal box containing the gas whose fluorescence is to be studied, the fluorescent light being observed or its spectrum photographed through a quartz window in the box. Experiments with fluorite, which is partially transparent to the radiations, show that they lie outside the Schumann region, for which fluorite is quite transparent. Fused quartz and mica are opaque to all these rays. Crystalline quartz is slightly transparent to them, and by using a quartz prism of small angle it was possible to show that this new radiation is capable of refraction (*Phil. Mag.*, October, 1915).

RADIO-ACTIVITY.

By ALEXANDER FLECK, B.Sc.

EFFECT OF RADIUM ON PLANT LIFE.—There can be no doubt that radio-active rays in general have some effect on animal life, and it is reasonable to claim that they should have similar effects on plants. Various papers published since 1911 have brought forward evidence to make good such claims. In the issue of *Nature*, published on October 7th, Dr. E. J. Russell directs attention to the attempted use of radio-active material as a fertiliser. The material which it was proposed to use for this purpose is the residues left in the commercial purification of radium. There is, however, a very great difference in the conditions under which the rays are applied to a few plants in the laboratory and their applications on an agricultural scale, so that it is not surprising that the tests carried out by Mr. Martin Sutton, of Reading, failed to show that radium, applied in a weak concentration, had any effect, beneficial or otherwise. The trials have been carried on for over two seasons and a great number of types of plants were experimented upon. Dr. Russell and a number of agricultural men who examined the ground believe that the use of these residues is futile, and it seems from the control experiments that the plants benefited more from one shilling's worth of chemical manure than from nine shillings' worth of radium fertiliser.

LEAD FROM URANIUM ORES.—In this column mention has been made from time to time of the results of atomic-weight determinations on lead derived from various radio-active minerals. Once it has been proved that material which possesses all the properties which we associate with lead may have a variable atomic weight, one of the most fundamental conceptions of modern chemical theory requires reconsideration. No apology is therefore required in drawing attention to some recent results obtained by Honigschmid and Horovitz. Earlier determinations made from residues, in which crude sulphuric acid, not free from lead, had been used, gave a value for the atomic weight of lead of 206·73, in place of the usually accepted value of 207·20. In the results of the determinations now published the value of 206·40 has been obtained for lead derived from twenty kilogrammes of selected Joachimstal pitchblende. Other minerals—one from Norway and the other from what was formerly German East Africa—gave the values of 206·06 and 206·05 respectively.

These determinations again furnish strong evidence of the truth of the " isotope " theory, and show that the atomic weight of an atom has little influence in determining its chemical properties. A very large field of speculation is thus opened up, namely, that what is actually true in the case of lead may be true in some other elements in which all atoms may not have the same weight. What we know as an element may, in reality, be a mixture of isotopes.

PASSAGE OF β PARTICLES THROUGH MATTER.—The behaviour of α particles, when they pass into or through some material, has been carefully studied, and the results obtained have given us much information on the internal structure of atoms. The study of the passage of β particles is much more difficult to carry out; and, as very few experiments on this subject have been made, a paper in the October issue of *The Philosophical Magazine*, by Mr. W. F. Rawlinson, is very welcome.

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The decrease of velocity which a β particle suffered in passing through sheets of various metals was determined by subjecting the particle to a magnetic field after it had come through one particular sheet. In these circumstances the particle describes a circle of a certain radius, determined by the strength of the field and the velocity of the particle as it enters the field. Thus, if the field has a constant value, the radius of the described circle gives a measure of the velocity. Mr. Rawlinson determined the radius by a photographic method.

The theory of the behaviour of these particles has been studied by Dr. N. Bohr, and he concludes that for any particular metal, $I\beta^3$ should have a constant value, where I is the decrease in velocity suffered in passing through a screen of which the weight per unit area is 0·01 gramme, and β the ratio of the (initial) velocity of the β ray to that of light.

The numerical values obtained by Mr. Rawlinson for a few metals vary within comparatively narrow limits, considering the experimental difficulties. Much more work, however, must be done before the theory put forward by Bohr can be regarded as substantiated.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A., LL.D.

SKIAGRAPHS OF FOSSILS.—Richard M. Field has made some interesting experiments (*Amer. Journ. Science*, May, 1915) on the use of the Röntgen ray in palaeontological investigation. A pencil of rays, having an intensity of 6 Benoist, can penetrate at least two centimetres of shale, sandstone, or limestone. The surface inequalities of the specimens are faithfully reproduced on the skiagraphs. The moulds of striated Brachiopods and of the cephalon and pleura of Trilobites were well brought out. The slightly elevated form of any fossil preserved upon the surface of a thin section of rock is readily skiagraphed. A portion of the fossil that is hidden in the rock is registered when the fossil is composed of a substance whose density is greater or less than that of the matrix in which it lies. Internal structures in the fossil may be discovered when there are differences of density in the substance, but the results will depend greatly on the ability of the investigator to interpret what he sees. Mr. Field worked mainly with Brachiopods and Trilobites.

DE CASTRO'S RED SEA LOG.—Mr. Cyril Crossland, Government Biologist at Port Sudan, gives his impressions of De Castro's "Log of the Voyage of the Portuguese Fleet" to Suez in 1541, a manuscript translation of which—surely deserving publication—has been made by Mr. R. S. Whiteway. The motive powers of the ships were sails and oars, and to reach the Red Sea was a great achievement. What is characteristic of De Castro's narrative is its accuracy, and it is striking to find that things were so much the same three hundred and seventy years ago. The rare thickets of "mangroves" on the shores are noted in the same places as they grow to-day. De Castro referred the name "Red Sea" to the brilliant red of the reefs; and, since he mentions "jellyfish" and the like, it is safe to say that the areas of red water, due to myriads of Protozoa (another likely origin of the title "Red") did not occur when he was in the sea.

DISTRIBUTION OF ONYCHOPHORA.—The archaic creatures known as Onychophores, represented by *Peripatus*, *Peripatopsis*, and other genera, have a very interesting geographical distribution, which has been recently studied in detail by Mr. Austin H. Clark. They require a somewhat uniform temperature, within very moderate extremes, and a uniformly high humidity. Yet they have a very wide distribution. This may be in part explained by their nocturnal mode of life and in part by their predaceous habits. "They apparently feed upon any organisms small enough for them to overcome." They are found in the Malay Peninsula and Sumatra; Ceram; New Guinea; New Britain; Australia, Tasmania, and New Zealand; Central and Southern Africa; Central and South America, from Tepic, Mexico, southward to Chile, including the West Indies. Mr. Clark points out that all occur south of the Tropic of Cancer, that the great majority are restricted to the southern hemisphere, and that the different types show a zonal distribution, the Peripatidae being equatorial, the Peripatopsinae intermediate, and the Peripatoidinae austral.

UNLOCKING THE DOOR TO CHOICE.—In his wise and luminous lectures on "Heredity and Environment in the Development of Men" (Oxford University Press, 1915), Professor E. G. Conklin refers to some interesting observations that Professor Whitman made on pigeons. When the eggs were removed a little distance from the nest, the wild passenger pigeon (now extinct in all probability) returned and sat down as if the eggs were there. Finding out by feeling that something was missing, she left the nest after a few minutes without heeding the eggs near by. She was too "wild" to be free: she was in thraldom to the procedure fixed by natural selection in ordinary conditions of life. The ring-neck pigeon also missed the eggs, but sometimes rolled one back into the nest. There was less rigidity of behavour here, but it is interesting to notice that she never attempted to recover more than one. The dovecot pigeon, on the other hand, generally tried to recover both eggs. This is very interesting, for it suggests that the relaxation of natural selection which domestication affords may open the door to plasticity and choice. Alternatives become possible. One remembers, it must be admitted, the stupid sheep and the silly hens; but Whitman's idea is corroborated when we think of cats and dogs and horses. It looks as if the intensity of the struggle for existence, such a spur in its way, might also operate as an imprisoner of choice.

RAT-FLEAS AND RAT-TRYPANOSOMES. — We owe to the late Professor E. A. Minchin and to Dr. J. D. Thomson an account of the linkage between the rat-trypanosomes (*T. lewisi*) and the rat-flea. The fully developed trypanosomes are found in great numbers in the blood of an infected rat, but they are never transmitted directly from one rat to another. Their intermediate host is the common rat-flea (*Ceratophyllus fasciatus*), which ingests the parasites with the rat's blood. Within the alimentary canal of the flea the trypanosomes, if they succeed in establishing themselves—which they apparently do in only about twenty-five per cent. of cases—go through a developmental cycle, and this has been minutely studied and figured by the authors. Of more general interest is the question as to how the parasite is transmitted to a fresh rat by the flea; and to determine this a series of experiments was made. Clean rats muzzled, so that they could neither lick nor scratch, with wire gauze too fine for fleas to penetrate were put into bell-jars with two hundred hungry fleas from the infected cage, and left there all night. When taken out they were freed from fleas, their fur was washed with a disinfectant, and carefully dried, and they were then allowed to lick as they pleased. In no case did such rats show infection except when they had succeeded in tearing off the muzzle. All the experiments went to prove that infection takes place through the mouth, either by the rat eating the fleas, or licking the moist faecal matter from its fur. Infection is never conveyed through the proboscis of the flea, which, indeed, never shows trypanosomes in its salivary glands. There remains the possibility that trypanosomes from the faecal matter penetrate through the puncture made by the flea's proboscis, but the balance of evidence is in favour of infection by the mouth alone.

THE RHEA'S CALLS.—In some very interesting notes on the habits of the rhea, or American ostrich, Mr. A. Pride refers to the distinctive calls uttered by the parent bird. When the chicks are very small a particular call causes them to take up a prone position on the ground, with the neck stretched out. As long as they lie quiet they are very difficult to detect. A second call appears to give warning of danger from above. On hearing it the young birds flock together, and tilt their head upwards to see what threatens them. At the same time the flightless wings are somewhat outspread, and the few white plumes upon them droop toward the ground. The body of the bird then seems almost twice its usual size. A third cry or call is a low whistle, which causes every young bird to stop eating, stand erect, and look across the country. As in the case of the hen and her chicks, a definite sound pulls the trigger of a definite instinctive response.

THE ABALONES OF CALIFORNIA.—Professor C. L. Edwards has made an interesting study of the ear-shells, or abalones, of California, marine snails which have their representatives in many seas. The ormer (*Haliotis*) of the Channel Islands is a well-known species. The polished shell gleams with the iridescence of the rainbow and the aurora; pearls are often found between the shell and the skin; and the flesh has much food value. A diver with a suit on can work for four hours at a time in depths of three to ten fathoms; and, using a chisel to detach the abalones, can send up in baskets one and a half tons to two tons in his strenuous shift. It takes the united efforts of six divers without suits to equal in four hours the catch of one diver in a suit. In Japanese waters the abalones are chiefly gathered by women divers, who swim out to the fishing grounds and work in depths of from six to eight fathoms. The abalones are vegetarian, and their flesh is delicious. They can survive transport for six days, but large quantities are dried in the sun and sent to China. The polished shells have gone all over the world as ornaments, and they are surely well-appreciated feasts of colour, perhaps unsurpassed in iridescent splendour except by soap bubbles and peacocks' feathers. Sometimes the boring mollusc (*Pholadidea*) bores through the abalone's shell, probably with the help of sulphuric acid in the salivary secretion, and is met at the end by a nacreous secretion, which forms a beautiful "blister-pearl." Very interesting and really valuable experiments have been made that show the feasibility of meeting the abalone half-way in the production of beautiful pearls.

CORRESPONDENCE.

THE REVOLUTION OF PLANETS.

To the Editors of "KNOWLEDGE."

SIRS,—During my planetary studies I have just come across an interesting and peculiar case in the revolution of their surfaces.

Lowell and George Darwin contradict each other. The former, in a note on tidal effects on page 271 of his "Mars as the Abode of Life," remarks on the attitude of Mercury and Venus in presenting, as they do to the Sun, always the same face. This, he says, is caused by solar tides, which brought the axial and orbital periods to identity. The changeless face of the Moon is due to the same cause.

Lowell continues saying that the fate of Venus and Mercury must ultimately befall the rest of the planets of our system. He instances it as a method of planetary death. It is; for, when so postured with regard to the Sun, the sunward side of the planet is baked, and the averted side chilled for ever. Any water that might be there would inevitably be locked in the dark hemisphere permanently in the form of ice, thus rendering the planet unfit for occupation by any temporary, organic compound, capable for a while of meta- and catabolic reactions, that is to say, man—if I may quote the definition given of the human creature by a physiologist who once taught in the medical school in Oxford.

Lowell suggests that this fate must overtake the other planets of the solar system.

Here, if I mistake not, he errs, as may be shown from George Darwin's work.

A planet, like a man, cannot serve two masters. Now the Earth has two: one to rule the day, another the night.

I hope you will pardon me quoting George Darwin from memory.

When the Moon was born, he tells us, it sprang from the surface of the Earth, owing to excessive centrifugal strain, when out planet was rotating on its axis in a period of about one hour and forty minutes.

Since that time tidal effects of the Sun and Moon have increased the diurnal period of the Earth to its present value.

Now, since the moment of momentum of the Earth-Moon system is a constant, the Moon must continue to retreat from the Earth until the Earth's rotation is slowed enough to cause it to present always the same face to the Moon, at which time the day will be eighty times as long as now, and will be the same length as the month. After this what will happen? The Moon will tend to maintain the stable arrangement. The Sun will tend to further lengthen the day. The conclusion seems inevitable that the solar tides, become enfeebled by the Earth's slow rotation, will be unequal to the task, and that the Earth can never assume the posture of Venus and Mercury.

The matter, I think, hinges on the possession of a satellite capable of exercising a greater tidal influence at the beginning than the Sun. Venus and Mercury have no such dependents. The Earth may well be spared their plight by the Moon's assistance.

I would be ready to bet on it, but would be very grateful for a little accurate information from your readers.

While I am on the subject, I might put forward a suggestion that the decreasing speed of the Earth's rotation, which eludes measurement by clocks based upon that rotation, might be better measured by the rotation of some body other than the Earth.

Mars would probably be a better clock. His rotation is probably more uniform than that of the Earth, for his moons are almost negligible as tide raisers; and, since the nearest and largest of them revolves faster in its orbit than Mars does on his axis, whatever tidal effect he may have is opposed in sign to that of the Sun.

Compared with the Earth, Mars' smaller radius and greater distance from the Sun render him more free from the influence of tidal action. Besides his dial is easy to read with considerable accuracy.

Lowell, Slipher, and I have found no difficulty in agreeing within less than two minutes on a single night's observation of the passage of his zero meridian under the noon-point. Such an observation, repeated, let us say, a hundred thousand years hence, might easily reveal a change in the length of our day, and we know positively from celestial mechanics that such a change, if found, must be mainly imputed to the Earth, and not to Mars.

Set a planet to catch a planet. Tidal action on Jupiter offers kindred problems, but he has four big moons and a swarm of little ones, so I will not occupy your space in further speculation.

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THE FACE OF THE SKY FOR DECEMBER.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

TABLE 57.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Mars. R.A.	Mars. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Uranus. R.A.	Uranus. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Dec. 2	16 30·2	S. 21·8	12 32·4	S. 8·3	15 58·6	S. 23·4	17 58·5	S. 24·5	9 52·5	N. 15·5	23 22·2	S. 5·6	7 7·0	N. 22·0	21 0·4	S. 17·7
,, 7	16 51·9	22·5	17 37·6	S. 26·9	16 31·4	22·4	18 25·9	24·5	9 58·3	15·2	23 23·5	5·4	7 5·7	22·1	21 1·1	17·7
,, 12	17 13·8	23·0	22 32·6	S. 6·6	17 4·9	23·8	18 53·3	24·3	10 3·1	14·9	23 25·0	5·2	7 4·2	22·1	21 1·9	17·6
,, 17	17 35·9	23·3	2 25·5	N. 19·8	17 39·3	24·8	19 20·5	23·7	10 7·1	14·7	23 26·7	5·0	7 2·7	22·2	21 2·7	17·6
,, 22	17 58·1	23·5	6 44·3	N. 25·5	18 14·3	25·2	19 47·3	22·8	10 10·1	14·7	23 28·8	4·8	7 1·0	22·2	21 3·6	17·5
,, 27	18 20·3	S. 23·4	10 43·6	N. 5·1	18 49·7	S. 25·0	20 13·7	S. 21·6	10 12·0	N. 14·7	23 31·1	S. 4·5	6 59·3	N. 22·3	21 4·5	S. 17·4

TABLE 58.

Date.	Greenwich Noon. Sun. P	B	L	Greenwich Midnight. Moon. P	Mars.	P	B	L	T	Jupiter.	P	B	L_1	L_2	T_1	T_2
	°	°	°	°		°	°	°	h. m.		°	°	°	°	h. m.	h. m.
Dec. 2	+16·0	+0·7	348·7	+22·1	Dec. 2	+ 6·6	+19·4	64·8	7 34 *e*	Dec. 4	−25·2	+1·8	198·8	121·1	6 35 *e*	8 40 *e*
,, 7	13·9	0·0	282·8	0·0	,, 8	7·6	19·6	8·5	11 25 *e*	,, 11	25·3	1·8	223·0	91·9	5 55 *e*	9 23 *e*
,, 12	11·8	−0·6	217·0	−21·3	,, 14	8·4	19·7	312·5	2 37 *m*	,, 18	25·3	1·8	247·0	62·5	5 16 *e*	10 17 *e*
,, 17	9·5	1·2	151·1	−17·3	,, 20	9·0	19·6	256·9	6 25 *m*	,, 25	25·3	1·8	270·9	33·1	4 36 *e*	11 6 *e*
,, 22	7·2	1·9	85·2	+ 5·5	,, 26	9·4	19·5	201·7	10 12 *m*	Jan. 1	−25·4	+1·8	294·7	3·4	3 57 *e*	11 55 *e*
,, 27	+ 4·8	−2·5	19·4	+21·6	Jan. 1	+ 9·5	+19·3	146·9	1 57 *e*							

P is the position angle of the North end of the body's axis measured eastward from the North point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. T is the time of transit of the zero meridian across the centre of the disc. In the case of Jupiter System I refers to the rapidly rotating equatorial zone, System II to the temperate zones, which rotate more slowly. To find intermediate passages of the zero meridian of either system across the centre of the disc, apply to T_1 T_2 multiples of $9^h\ 50^m{\cdot}6$, $9^h\ 55^m{\cdot}8$ respectively. In the case of Mars apply multiples of $24^h\ 38^m$.

The data for the Moon and Planets in the Second Table are given for Greenwich Midnight, *i.e.*, the Midnight at the end of the given day.

The letters *m*, *e* stand for morning, evening. The day is taken as beginning at midnight.

THE SUN is moving Southward at a slackening rate, till $10^h\ 16^m$ *e* on the 22nd, when it passes the Winter Solstice and commences to move Northward. Its semi-diameter increases from 16′ 15″ to 16′ 17″. Sunrise changes from $7^h\ 49^m$ to $8^h\ 8^m$; sunset from $3^h\ 49^m$ to $3^h\ 58^m$. There is now considerable solar activity, and a constant watch should be kept on the disc.

MERCURY is a morning star till December 15th, then an evening star. Semi-diameter nearly constant at 2½″. Illumination nearly Full.

VENUS is an evening star, but badly placed, from its South Declination. Semi-diameter 5½″. Illumination nearly Full.

THE MOON.—New $6^d\ 6^h\ 4^m$ *e*. First quarter $13^d\ 11^h\ 38^m$ *m*. Full $21^d\ 0^h\ 52^m$ *e*. Last quarter $29^d\ 0^h\ 59^m$ *e*. Perigee $7^d\ 1^h$ *m*. Apogee 21^d midnight, semi-diameter 16′ 46″, 14′ 43″ respectively. Maximum librations 1^d 8° E., 4^d 7° N., 13^d 8° W., 17^d 7° S., 29^d 8° E. The letters indicate the region of the Moon's limb brought into view by libration. E., W. are with reference to our sky, not as they would appear to an observer on the Moon (see Table 59).

MARS is a morning star in Leo, near Regulus on the 12th, rising about 9^h *e*. Semi-diameter 5″, width of defective lune nearly 1″. The North Pole of the planet is now turned towards the Earth and Sun. The Vernal Equinox of the planet's northern hemisphere took place on October 19th, and the planet is in the part of its orbit that corresponds with late April on Earth.

JUPITER is an evening star, in Pisces; has commenced to advance in R.A. In quadrature with the Sun on the 13th. Equatorial diameter 40″, Polar 38″. Defect of illumination on East Limb 0″·4.

Configuration of satellites at 8^h *e* for an inverting telescope.

JUPITER'S SATELLITES.

Day.	West.	East.	Day.	West.	East.
Dec. 1	○	412 3●	Dec. 17	24 ○	13
,, 2	21 ○	43	,, 18	○	423 1●
,, 3	2 ⊙	34	,, 19	31 ○	24
,, 4	○	1324	,, 20	32 ○	14
,, 5	31 ○	24	,, 21	312 ○	4
,, 6	32 ○	14	,, 22	3 ○	124
,, 7	31 ○	4 2●	,, 23	1 ⊙	24
,, 8	○	124 3●	,, 24	2 ○	134
,, 9	¾ ○	43	,, 25	1 ○	243
,, 10	42 ○	13	,, 26	¾ ⊙	2
,, 11	4 ○	32 1●	,, 27	342 ○	1
,, 12	431 ○	2	,, 28	4312 ○	
,, 13	432 ○	1	,, 29	43 ○	12
,, 14	4312 ○		,, 30	41 ○	23
,, 15	43 ○	12	,, 31	42 ○	13
,, 16	412 ○	3			

The following satellite phenomena are visible at Greenwich all in the evening hours:—$1^d\ 4^h\ 24^m$ III. Oc. R.,

$6^h\,54^m\,19^s$ III. Ec. D., $9^h\,34^m\,7^s$ III. Ec. R., $11^h\,49^m$ I. Tr. I.; $2^d\,4^h\,12^m$ II. Sh. E., $9^h\,10^m$ I. Oc. D.; $3^d\,6^h\,18^m$ I. Tr. I., $7^h\,38^m$ I. Sh. I., $8^h\,35^m$ I. Tr. E., $9^h\,55^m$ I. Sh. E.; $4^d\,7^h\,13^m\,11^s$ I. Ec. R.; $5^d\,4^h\,24^m$ I. Sh. E., $11^h\,59^m$ II. Tr. I.; $7^d\,6^h\,7^m$ II. Oc. D., $11^h\,38^m\,32^s$ II. Ec. R.; $8^d\,5^h\,14^m$ III. Oc. D., $8^h\,22^m$ III. Oc. R., $10^h\,56^m\,50^s$ III. Ec. D.; $9^d\,4^h\,0^m$ II. Sh. I., $4^h\,9^m$ II. Tr. E., $6^h\,48^m$ II. Sh. E., $10^h\,44^m$ IV. Tr. I., $11^h\,4^m$ I. Oc. D.; $10^d\,8^h\,13^m$ I. Tr. I., $9^h\,34^m$ I. Sh. I., $10^h\,30^m$ I. Tr. E.; $11^d\,5^h\,33^m$ I. Oc. D., $9^h\,8^m\,44^s$ I. Ec. R.; $12^d\,4^h\,3^m$ I. Sh. I., $4^h\,59^m$ I. Tr. E., $6^h\,19^m$ I. Sh. E.; $14^d\,8^h\,45^m$ II. Oc. D.; $15^d\,9^h\,17^m$ III. Oc. D.; $16^d\,3^h\,55^m$ II. Tr. I., $6^h\,37^m$ II. Sh. I., $6^h\,46^m$ II. Tr. E., $9^h\,25^m$ II. Sh. E.; $17^d\,10^h\,9^m$ I. Tr. I.; $18^d\,7^h\,29^m$ I. Oc. D., $8^h\,8^m\,29^s$ IV. Ec. D., $9^h\,16^m\,8^s$ IV. Ec. R., $11^h\,4^m\,17^s$ I. Ec. R.; $19^d\,4^h\,38^m$ I. Tr. I., $4^h\,50^m$ III. Sh. I., $5^h\,59^m$ I. Sh. I., $6^h\,55^m$ I. Tr. E., $7^h\,38^m$ III. Sh. E., $8^h\,15^m$ I. Sh. E.; $20^d\,5^h\,33^m\,12^s$ I. Ec. R.; $23^d\,6^h\,34^m$ II. Tr. I., $9^h\,14^m$ II. Sh. I., $9^h\,25^m$ II. Tr. E.; $25^d\,6^h\,13^m\,26^s$ II. Ec. R., $9^h\,26^m$ I. Oc. D.; $26^d\,5^h\,31^m$ IV. Tr. I., $6^h\,29^m$ III. Tr. E., $6^h\,35^m$ I. Tr. I., $7^h\,55^m$ I. Sh. I., $8^h\,36^m$ IV. Tr. E., $8^h\,53^m$ I. Tr. E., $8^h\,53^m$ III. Sh. I., $10^h\,11^m$ I. Sh. E.; $27^d\,3^h\,55^m$ I. Oc. D., $7^h\,28^m\,42^s$ I. Ec. D.; $28^d\,4^h\,40^m$ I. Sh. E.; $30^d\,9^h\,15^m$ II. Tr. I.

The Eclipse reäppearances of Satellites I, II., and both phases of those of III. IV., occur low right of the disc in an inverting telescope, taking the direction of the belts as horizontal.

SATURN is a morning star in Gemini. Rises about 6^h *e*. Angle P$-7°\cdot0$, B$-24°\cdot5$. Polar semi-diameter $9\frac{3}{4}''$, Major axis of ring $46''$, minor $19\frac{1}{4}''$. Eastern elongations of Tethys (every fourth given) $2^d\,3^h\cdot9$ *m*, $9^d\,5^h\cdot0$ *e*, $17^d\,6^h\cdot2$ *m*, $24^d\,7^h\cdot3$ *e*, January $1^d\,8^h\cdot5$ *m*; of Dione (every third given) $1^d\,7^h\cdot3$ *e*, $10^d\,0^h\cdot3$ *m*, $18^d\,5^h\cdot2$ *m*, $26^d\,10^h\cdot1$ *m*; of Rhea (every second given) $8^d\,7^h\cdot1$ *m*, $17^d\,7^h\cdot8$ *m*, $26^d\,8^h\cdot4$ *m*. For Titan and Japetus E., W. stand for Eastern and Western elongations; S., I. for Superior and Inferior Conjunctions. Titan $1^d\,9^h\cdot3$ *m* S., $5^d\,10^h\cdot1$ *m* E., $9^d\,8^h\cdot2$ *m* I., $13^d\,6^h\cdot1$ *m* W., $17^d\,6^h\cdot7$ *m* S., $21^d\,7^h\cdot5$ *m* E., $25^d\,5^h\cdot7$ *m* I., $29^d\,3^h\cdot4$ *m*. W. Japetus $8^d\,5^h$ *m* E., $28^d\,7^h$ *m* I.

URANUS is an evening Star. Near θ Capricorni. Semi-diameter $1\frac{3}{4}''$. Occulted by Moon on 10th (see table below).

NEPTUNE is a morning Star in Cancer. On 3rd R.A. $8^h\,18^m\cdot7$, N. Dec. $19°\cdot3$, on 27th R.A. $8^h\,16^m\cdot7$, N. Dec. $19°\cdot4$. Semi-diameter $1''$.

COMETS.—Mellish's Comet, *a* 1915, may be seen in Orion rising about 7^h *e* on November 20th. It was easily visible to the unaided eye in the Southern hemisphere in June, but has now become faint, and invisible without telescopic aid. It was near Rigel on November 6th.

See "Notes on Astronomy" for Mellish's other comet, *d* 1915.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
	°	°	
Nov. 29—Dec. 2	44	+ 56	
Dec. 3 ...	162	+ 58	
,, 4 to 13 ...	114	+ 30	Conspicuous shower.
,, 6 ...	80	+ 23	
,, 14 to 31 ...	221	+ 43	
,, 15 ...	52	+ 31	
,, 16 to 22 ...	193	+ 69	
,, 17 ...	133	+ 48	
,, 18 to 20 ...	140	+ 8	
,, 21 ...	117	+ 47	Conspicuous shower.

TABLE 59. Occultations of Stars by the Moon visible at Greenwich.

Date.	Star's Name.	Magnitude.	Disappearance. Time.	Disappearance. Angle from N. to E.	Reäppearance. Time.	Reäppearance. Angle from N. to E.
1915.			h. m.	°	h. m.	°
Dec. 1 ...	BAC 3955	6·3	6 56 *m*	144	8 7 *m*	289
,, 9 ...	BAC 6878	6·5	3 30 *e*	109	4 20 *e*	201
,, 10 ...	θ Capricorni	4·2	5 36 *e*	99	6 27 *e*	200
,, 10 ...	Uranus	—	6 2 *e*	142	6 10 *e*	156
,, 13 ...	λ Piscium	4·6	9 57 *e*	31	10 53 *e*	269
,, 15 ...	WZC 70	7·1	6 53 *e*	41	—	—
,, 17 ...	BAC 650	6·5	1 40 *m*	49	2 35 *m*	281
,, 18 ...	WZC 176	6·7	2 38 *m*	107	—	—
,, 18 ...	16 Tauri	5·4	11 55 *e*	108	1 4 *m**	235
,, 19 ...	19 Tauri	4·4	0 10 *m*	70	1 24 *m*	274
,, 19 ...	20 Tauri	4·0	0 31 *m*	98	1 43 *m*	248
,, 19 ...	21 Tauri	5·9	0 41 *m*	55	1 45 *m*	292
,, 19 ...	22 Tauri	6·5	0 43 *m*	63	1 51 *m*	284
,, 19 ...	BD$+24°\cdot562$	7·0	1 10 *m*	69	—	—
,, 19 ...	BD$+23°\cdot540$	7·0	1 35 *m*	131	—	—
,, 19 ...	WZC 227	6·6	2 5 *m*	124	—	—
,, 19 ...	χ Tauri	5·4	3 55 *e*	22	4 30 *e*	309
,, 21 ...	BD$+26°\cdot884$	6·8	4 40 *m*	34	—	—
,, 21 ...	WZC 421	7·4	—	—	5 39 *e*	291
,, 22 ...	ω Geminorum	5·2	—	—	5 28 *e*	264
,, 22 ...	48 Geminorum	5·8	9 13 *e*	81	10 26 *e*	295
,, 25 ...	WZC 646	6·7	—	—	8 42 *e*	272
,, 26 ...	R Leonis	Var.	3 27 *m*	78	4 20 *m*	351
,, 29 ...	WZC 781	6·8	—	—	4 50 *m*	311
,, 30 ...	BD$-10°\cdot3570$	6·0	3 34 *m*	109	4 42 *m*	320
,, 30 ...	BD$-11°\cdot3398$	6·7	—	—	6 31 *m*	334

The asterisk indicates the day following that given in the date column.

From New to Full disappearances occur at the Dark Limb, from Full to New reäppearances.

Attention is called to the occultation of Uranus on the evening of the 10th, and of the Pleiades on the morning of the 19th.

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TABLE 60.

Day.	β Pegasi.	α Andromedae.	Aldebaran.
	N. Dec. 27° 38′.	N. Dec. 28° 38′.	N. Dec. 16° 21′.
	h. m. s.	h. m. s.	h. m. s.
Nov. 27	6 37 20·50 *e*	7 41 30·93 *e*	0 7 51·53 *m**
Dec 7	5 58 1·25 *e*	7 2 11·70 *e*	11 28 32·54 *e*
„ 17	5 18 42·00 *e*	6 22 52·45 *e*	10 49 13·50 *e*
„ 27	4 39 22·74 *e*	5 43 33·19 *e*	10 9 54·42 *e*

* Morning of Nov. 28th.

GREENWICH TIMES OF MERIDIAN TRANSIT OF CERTAIN BRIGHT STARS.—These are given to facilitate the determination of time by observations with small transit instruments. The times for intermediate days may be obtained by simple interpolation. The Greenwich time of the stars crossing the meridians of other places may be obtained by expressing the longitude of these places in time, diminishing them by $9^s \cdot 83$ per hour, and proportionately for fractions of an hour, then applying the result to the tabular time—positively for West longitudes, negatively for East ones (see Table 60).

SUN before clock Dec. 1, $672^s \cdot 79$, Dec. 6, $554^s \cdot 73$, Dec. 11, $423^s \cdot 02$, Dec. 16, $281^s \cdot 63$, Dec. 21, $134^s \cdot 42$; Sun after clock Dec. 26, $14^s \cdot 79$, Dec. 31, $162^s \cdot 12$. These are the equations of time for the moment of solar transit at Greenwich.

DOUBLE STARS AND CLUSTERS.—The tables of these, given three years ago, are again available, and readers are referred to the corresponding month of three years ago.

VARIABLE STARS.—Stars reaching their maxima in or near December, 1915, are included. The lists in recent months may also be consulted (see Table 61).

TABLE 61. LONG-PERIOD VARIABLE STARS.

Star.	Right Ascension.	Declination.	Magnitudes.	Period.	Date of Maximum.
	h. m. s.	° ′		d.	
o Ceti (Mira)	2 15 3	− 3 21	2·0 to 9·6	331	1916—Jan. 8
R Ceti	2 21 42	− 0 34	7·5 to 12·8	167	„ Feb. 14
R Ursae Maj.	10 38 42	+69 13	5·9 to 13·1	299	1915—Dec. 23
V Ursae Min.	13 37 10	+74 45	7·5 to 8·7	71	„ Dec. 17
T Draconis	17 55 6	+58 13	7·5 to 12·0	426	„ Dec. 9
R Aquilae	19 2 16	+ 8 6	6·2 to 11·2	335	„ Dec. 27
χ Cygni	19 47 19	+32 42	4·2 to 13·2	405	Early in 1916
Z Cygni	19 59 3	+49 48	7·1 to 13·8	263	1915—Dec. 31

Special attention is called to the approaching Maximum of Mira Ceti.

Minima of Algol 2 $1^h \cdot 5\,m$, $4^d\,10^h \cdot 3\,e$, $7^d\,7^h \cdot 1\,e$, $10^d\,3^h \cdot 9\,e$, $19^d\,6^h \cdot 4\,m$, $22^d\,3^h \cdot 2\,m$, $25^d\,0^h \cdot 1\,m$, $27^d\,8^h \cdot 8\,e$, $30^d\,5^h \cdot 6\,e$. Period $2^d\,20^h\,48^m \cdot 9$.

Principal Minima of β Lyrae $11^d\,0^h \cdot 8\,m$, $23^d\,11^h \cdot 0\,e$. Period $12^d\,21^h\,47^m \cdot 5$.

REVIEWS.

CHEMISTRY.

The Poison War.—By A. A. ROBERTS. 144 pages. 10 illustrations. 9-in. × 5¾-in.

(William Heinemann. Price 5/- net.)

The author of this small book is to be congratulated upon the way in which he has dealt with the methods of fighting with the aid of poisonous gases, which have been introduced by the Germans in this war. The subject is treated both historically and practically, and we have not only an account of the properties of the different gases that have been used, but also a description of the apparatus employed for their projection. There is also a chapter upon incendiary bombs and fire sprays, which contains much first-hand information. The descriptions of the shell-projection apparatus are clear and concise, and, where required, are illustrated by diagrams. Both scientific and general readers will find much to interest them here, and will gain a clear idea of the difficulties with which our troops have to contend in opposing such barbarous methods of warfare.

C. A. M.

Practical Physical Chemistry.—By J. B. FIRTH, M.Sc. 178 pages. 74 illustrations. 7¼-in. × 4¾-in.

(Methuen & Co. Price 2/6.)

This book well fulfils its aim of being a practical companion to a good theoretical textbook on physical chemistry, and more than covers the ground traversed by most students. As its name suggests, it is intended to be used in the laboratory, and it gives exact directions for using the apparatus required for physico-chemical measurements, such as density, molecular weight, thermo-chemical and electrolytic determinations, and so on. A separate chapter is given to the use of the spectroscope, including the determination of wave-lengths. Any one wishing to obtain a good grasp of the physical side of chemistry cannot do better than work conscientiously through the exercises given in this book.

C. A. M.

FORESTRY.

Forest Valuation.—By HERMAN HAUPT CHAPMAN, M.F., Harriman Professor of Forest Management, Yale University Forest School. 310 pages. 9¼-in. × 6-in.

(Chapman & Hall. Price 8/6 net.)

It is a remarkable illustration of the great development of an interest in State forestry in America within recent years that there should be an opening for such a volume as this. As the author points out in his Preface :—

> The literature of Forest Finance is largely of German origin, and has been developed in the latter half of the nineteenth century by numerous German and French authorities.

The only English work on the subject is Volume III, Part II, of Sir William Schlich's "Manual of Forestry," in which the treatment is thoroughly German, and that work probably finds its chief students among the officers of the Indian Forest Service. Mr. Chapman's plan is to write a textbook for those not already familiar with the economic and mathematical principles of forest finance or compound interest dealing with prolonged periods of time, and to do so from an entirely American standpoint. He accordingly devotes his first four chapters—a sixth of the entire work—to economic first principles, dealing with values, outlay and income, interest, and the valuation of assets, and then passes on to the mathematical formulae of compound interest and forest accounts. A special chapter is devoted to the risks attaching to forest property, and the body of the work concludes with a comparison of forest with agricultural values. In the former of these chapters is the following reference to the fungoid disease mentioned in our notice of another work issued by the same school :—

> The only conspicuous instance of widespread destruction of an American species due to fungous attacks is found in the ravages of the imported disease of the chestnut, *Diaporthe parasitica*, which threatens to exterminate what is considered the most important commerical hardwood over wide regions east of the Appalachians.

This thoroughly business-like book concludes with full tables of compound interest and logarithms, and a good index.

G. S. BOULGER.

MATHEMATICS.

Indian Mathematics.—By G. R. KAYE. 73 pages. 2 illustrations. 8½-in. × 5½-in.

(Calcutta and Simla : Thacker, Spink & Co. London : W. Thacker & Co. Price 3/6 net.)

This is an interesting addition to works on the history of mathematics. Mr. Kaye rejects the older view, which ascribed both great antiquity and great originality to Indian mathematics, and maintains that mathematical knowledge flowed to India from the West. China is also suggested as a possible source of influence. In the matter of indeterminate equations, however, the study of which they carried to a high pitch of excellence, the early Indian mathematicians do appear to have surpassed their contemporaries of the West, and they must also be credited with the invention of the sine function.

Mathematical study appears originally to have arisen in India in connection with the construction of temples. But the work of this, the S'ulvasūtra period (ending A.D. 200), remained unutilised, according to Mr. Kaye, during the succeeding periods, though similar problems were still dealt with. Mathematical study next came into prominence in connection with astronomy. There is an interesting formula of this period for the quadrature of the circle, which would indicate a remarkable facility in the use of partial fractions did not Mr. Kaye assure us that it is an isolated example. As it is, it presents one of a number of problems concerning Indian mathematics that Mr. Kaye leaves for solution. The persistence of quite inaccurate formulae, along with very accurate ones, is another curious matter in the same connection. But if Mr. Kaye leaves—necessarily no doubt—much that remains mysterious, we are, nevertheless, thankful for the light he has thrown on a fascinating and obscure subject.

The book closes with translated extracts from early Indian mathematical texts, including examples of problems, a chronology, bibliography, and index ; and there is a section on Indian arithmetical and algebraical notations. The Indians do not appear, as has been maintained, to have invented the place-value notation for numbers.

Some of the examples are rather amusing. "The third part of a necklace of pearls broken in an amorous struggle fell on the ground. Its fifth part was seen resting on the couch, the sixth part was saved by the lady, and the tenth part was taken up by her lover. Six pearls remained on the string. Say of how many pearls the necklace was composed." Indeed, these old mathematicians were by no means lacking in humour. "Thus," writes Mahāvīra in a certain place, "ends the section of devilishly difficult problems." One can imagine the student's appreciation of the adverb.

H. S. REDGROVE.

MEDICINE.

Throat and Ear Troubles.—By MACLEOD YEARSLEY, F.R.C.S. 110 pages. 12 illustrations. 7-in. × 4½-in.

(Methuen & Co. 1/- net.)

It is probable that less is known of medical subjects by the educated public of England than by that of any other country in Europe. This is probably the result of many causes. It is due in part no doubt to the natural credulity of our race and the trust which we, for the most part, wisely repose in our doctors ; and it is also to some extent because most of the medical literature on which the public is fed has been produced by men who cannot be considered in the front rank of their profession. The little book before us is fortunately a marked exception to this rule. It has been written by a man who is a recognised specialist on the subject on which he writes. It is most clearly and concisely written, and gives in simple language the most recent knowledge concerning ear and throat affections. It is most strongly to be recommended to school teachers and parents, and could with advantage be read by most practitioners of medicine for whom the results of the most recent work on ear and throat affections put together in a readable form will be especially useful. As might be expected, the section dealing with deafness is especially ably written, and the author makes it clear that the only reliable treatment in this, as in so many other affections, lies in prevention. "As a matter of fact," he says, "the whole medicine of the future is preventive." Surprisingly few errors are to be found in the book, and the only one which we have detected is the statement that headaches due to nasal causes are characteristic, whereas the fact is that they are most variable in both character and degree. We can most strongly recommend this little book to all those who may be sufficiently interested in the subject to read it.

S. H.

PHYSICS.

Statics. Part II.—By R. C. FAWDRY, M.A., B.Sc. 305 pages. 298 illustrations. 7-in. × 4¾-in.

(G. Bell & Sons. Price 2/-.)

This is a well-written book on statics intended for students who have already an acquaintance with the elementary principles, but who desire to continue the study of the

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subject with a view to applying it to the solution of practical problems. The book has a distinct engineering bias, which, in our opinion, will make the work more acceptable and interesting. No very elaborate mathematical preparation is expected of the reader, the calculus is not employed, and the analysis throughout the book is simple, so that attention can be concentrated on physical principles.

J. H. V.

Experimental Harmonic Motion, a Manual for the Laboratory.—By G. F. C. SEARLE, Sc.D., F.R.S. 92 pages. 32 illustrations. 8½-in. × 5½-in.

(Cambridge University Press. Price 4/6 net.)

After an introductory chapter on the elementary theory of harmonic motion, various interesting and well-chosen experiments are described in which the theory is tested and illustrated. The detailed theory of the experiment is fully given; then follows an account of the apparatus and of the precautions necessary to obtain good results; an example, with readings, of an actual experiment is then quoted. Four mathematical notes of a more advanced character than the rest of the work are given at the end of the book.

This handbook will be welcomed in all physical laboratories where the students are equipped with the necessary mathematical knowledge to appreciate it. It is a well-written book by an expert teacher.

J. H. V.

ZOÖLOGY.

Wonders of Animal Life.—By W. S. BERRIDGE, F.Z.S. 270 pages. Numerous illustrations. 8-in. × 6-in. (Simpkin, Marshall & Co. Price 6/- net.)

There are few naturalists who do not know and enjoy the photographs which Mr. Berridge takes at the Zoölogical Gardens. The book under consideration is illustrated by some of the best of these, and its subject-matter is well calculated to create an interest in animal life.

The first chapter deals with the courtship of birds, which Mr. Berridge describes from his own observations. Fish that walk, fly, and live out of water is another topic which is touched upon. Under the heading of "Nature's Peter Pan," the axolotl, which may always remain in the tadpole stage, is described. Then we have the dwarfs and the large animals, and birds that cannot fly, a Kentish butterfly farm, animals verging on extinction, and, finally, the grotesque in nature.

Of the illustrations we might specially call attention to the pictures of the ostrich and the greater bird of Paradise displaying, and the kagu showing its crest, which forms the frontispiece. Visitors to the Zoo will be pleased with the excellent likeness of an old friend, the laughing hyena, which they cannot fail to recognise; while it is difficult to pick out any particular one of the studies of reptiles, all are so good. In conclusion we may say that the variety of subjects and their striking character should bring Mr. Berridge a large number of appreciative readers.

W. M. W.

NOTICES.

AGRICULTURAL BOOKS.—Nearly seven hundred books on agriculture are included in Messrs. John Wheldon and Company's catalogue numbered 71. Among them is an important collection of works on Early Husbandry; while the other items are classified under such headings as Modern Systems, Rural Economy, Live Stock, Crops, and Soils and Manures.

EALING SCIENTIFIC AND MICROSCOPICAL SOCIETY.—The thirty-eighth annual report of the Ealing Scientific and Microscopical Society contains, as usual, meteorological notes for the year, and abstracts of a number of interesting lectures given before the Society during the past session. It records the resignation of the President (Dr. Deane Butcher), owing to ill-health, and the election of Mr. B. B. Woodward in his place.

MUSEUM OF FISHERIES.—We welcome the fourth edition of the illustrated catalogue to the Museum of Fisheries and Shipping, which is one of the several institutions which Mr. Thomas Sheppard has done so much to bring together for the benefit of Hull. Not the least interesting of the objects described are whaling relics, and the getting together of the appliances which are dying or have died out is one of the most important pieces of work which any curator could do at the present time.

THE ALCHEMICAL SOCIETY.—The twenty-first general meeting of the Alchemical Society was held at the International Club, 22a, Regent Street, S.W., on Friday, October 8th, 1915. The chair was occupied by the Acting President (Mr. H. Stanley Redgrove, B.Sc., F.C.S.). Part of a paper by the late Mary Anne Atwood, the authoress of the celebrated "A Suggestive Enquiry into the Hermetic Mystery and Alchemy," was read. The rest of the paper will be read, and discussed, at the next meeting, after which it will be published for the first time under the editorship of Mme. Isabelle de Steiger—who possesses the original manuscript—in *The Journal of the Alchemical Society.*

MR. MURRAY'S QUARTERLY LIST.—Many of the forthcoming works which Mr. Murray announces deal with literary and political matters or with the war. We notice, however, that cheap editions of Mr. J. C. Tregarthen's "Story of a Hare" and "Life-story of an Otter" are to be brought out. Under the title of "In a College Garden," Lady Wolseley will give an account of the daily life and work at the Women's Horticultural College, which she founded at Glynde; and the adoption of work on the land by women, be it remembered, has a practical importance at the present time. We are promised a new edition of Professor J. Arthur Thomson's "Study of Animal Life," and to the Imperial Institute Handbooks, edited by Professor Wyndham R. Dunstan, Dr. Ernest Goulding is contributing a volume on "Vegetable Fibres."

GEOLOGICAL PHYSICS is a group of subjects so large that few could at once define what the term would exclude or include; and now is a time when one cannot expect to induce more than an interested few to give attention to new problems. A preliminary meeting to consider what could be done was held, with Professor Benjamin Moore, D.Sc., F.R.S., in the chair, on October 14th at the Geological Society's rooms, when it was resolved that a start should, and must, be made. An extensive programme could not be considered as expedient, but an attempt should be made to encourage the study of segregation in rocks, and perhaps that of shrinkage in septaria, and this by the coöperation of members who would assist by exchange of material, photographs, and literature. The suggestion to hold a few meetings and excursions each year met with approval. A difficulty arose as to the adoption of a suitable title, and this was deferred with the idea that it might be possible at the next meeting in the spring to secure a good one. A subscription of 2/6 per annum for the next two years was agreed to, and at the unanimous request of the meeting, Professor Benjamin Moore agreed to accept the presidency; whilst the post of Honorary Secretary was taken, *pro tem.*, by Mr. G. Abbott, 2, Rusthall Park, Tunbridge Wells, to whom communications can be made.

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